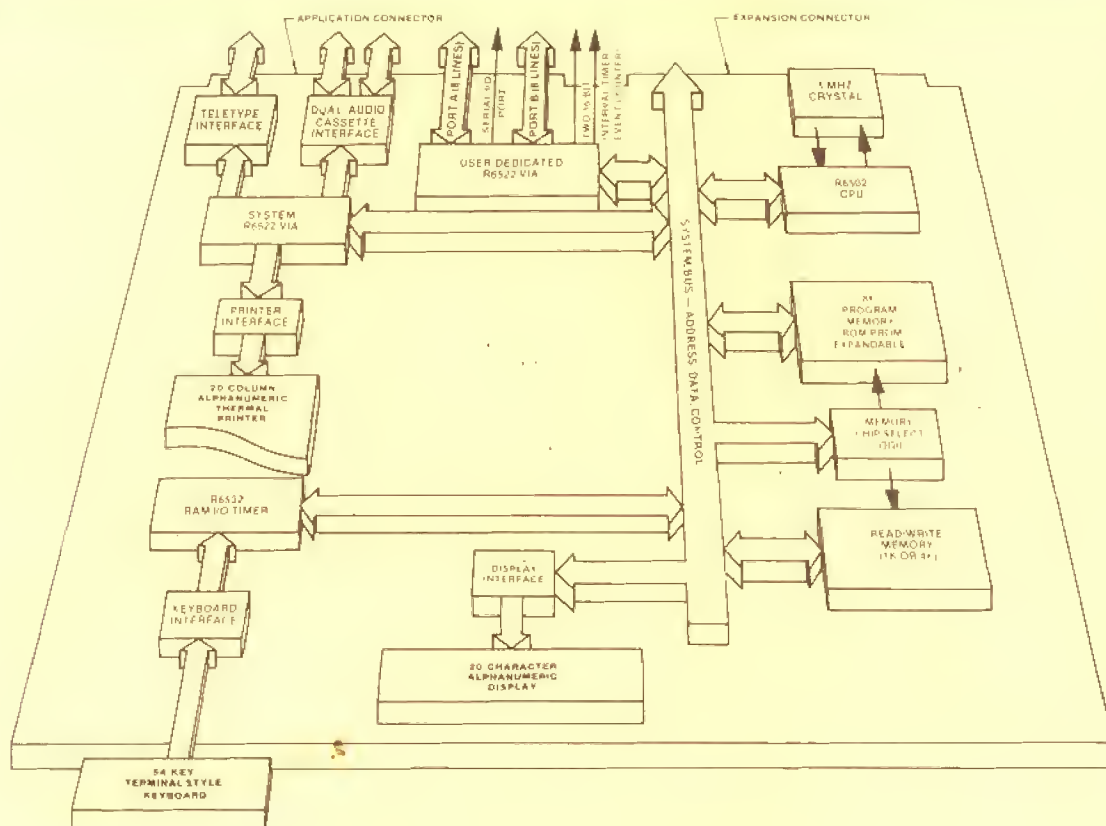


MICRO™

The Magazine of the APPLE, KIM, PET
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NO 7

Oct - Nov 1978

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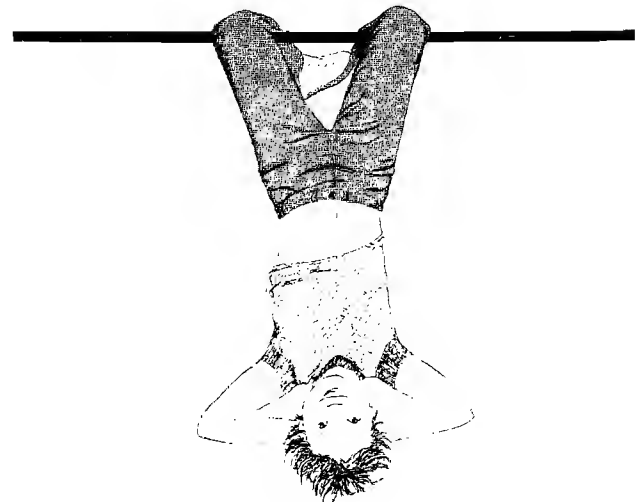


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MICRO™

OCTOBER/NOVEMBER 1978

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1000 REM THE FUNCTION PLOTTED IS
1010 Y=X*SIN(4.8*X)
READY

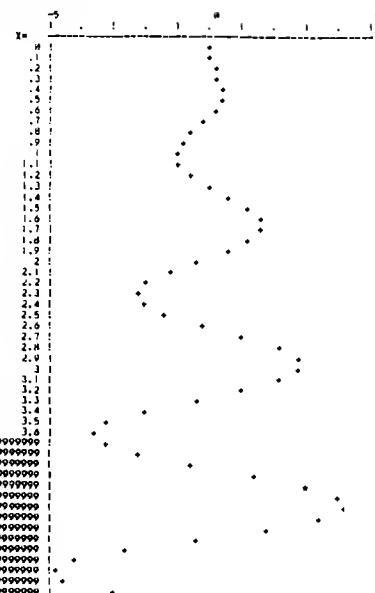
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T M O U S A I M D F N J A S
20 1 # TYPE C
# TYPE B
X TYPE A
151 X TYPE A
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1977 JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

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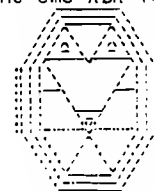
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
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This announcement was composed on a COMMODORE PET and printed on a GE TermiNet using a Cmc ADA 1200C printer adapter and the Cmc Word Processor Program.



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IN THIS ISSUE . . .

With this issue we introduce a new format for MICRO. We were dissatisfied with the quality of the last couple of issues of MICRO, particularly the last issue, and decided to try a different type of printing. This new format is similar to the old, but is on lighter paper, printed on a web press, saddle stitched instead of side stapled, and does not have the old MICRO border. We have kept the features that most people said they wanted - especially the three hole punch. Of course, we will not know the quality of the new printer's product until after this goes to press. If you have any comments, let us hear from you.

Rick Auricchio, who wrote "An Apple II Programmer's Guide" in MICRO number 4, has provided another super article in "BREAKER: An Apple II Debugging Aid". This article/program allows the Apple user to debug his program with real breakpoints which permit the user to interrupt his program at any point, gain control, and then continue execution. The program, written in assembler has a lot of useful techniques and is presented in its entirety.

Those of you planning to add more RAM to your Apple II will find some valuable comparative information about 16K RAMS in Allen Watson III's article on "MOS 16K RAM for the Apple II". This info includes a table on how to decode how the various manufacturers encode their access times.

William M. Shryock Jr. presents an "Improved Star Battle Sound Effects" program for the Apple II based on the original article by Andrew H. Eliason in issue number 6.

Gary A. Creighton has a number of items for the PET under the title "PET Update". Included are a discussion of the RND (Random Number) Function use, a short program for Machine Language Storing in BASIC, some rules for USR Parameter Passing, and a machine language program to Save Machine Language and Load Directly. A most useful set of goodies for the PET user.

Marvin L. De Jong's series on "6502 Interfacing for Beginners" continues with a discussion of "The Control Signals". The article presents the basic theoretical information, and then a program and hardware test configuration for experimenting with the control signals.

Quite often you may find that you have two sets of object code that are very similar, but not identical. It would be useful to have some way to let the computer compare the two sets of code and display the differences. This may sound simple, but since the addition of a single line of code would make all subsequent lines "different" even though they were identical except for the slight offset, it is not so simple. J. S. Green presents the solution and a program in "6502 Opcode Sequence Matcher".

Ever have doubts about your PET's memory? Then you will want to try "A Memory Test Program for the Commodore Pet" by Michael J. McCann. The program requires that the lowest 4K of memory be working and can be used to test all other memory in the PET.

Marc Schwartz presents some rules and ideas for "Apple Calls and Hex-Decimal Conversion", a useful tool when trying to generate the decimal equivalents for hex codes.

Once upon a time there were hardly any articles about 6502s at all. Now William R. Dial's "6502 Bibliography" is up to reference number 379, and this includes many multiple references. Since a reference of interest is of limited value if you do not know where to find the original, a list of "6502 Information Resources" has been compiled by William R. Dial that tells where to obtain the various magazines he has been using in the bibliography and how much they cost.

Every once in a while someone will ask "What can you do with a KIM-1 now that the PET is here?" Joseph L. Powlette and Charles T. Wright show how to use the "KIM-1 as a Digital Voltmeter".

An automated "Cassette Tape Controller" is the subject of Fred Miller's KIM article. He presents a complete hardware/software system to aid the user who wants to control cassette tapes from his KIM.

Andrew H. Eliason discusses the "Apple II High Resolution Graphics Memory Organization", and presents a few short programs that help to understand and use this feature of the Apple.

Chris Sullivan presents the first program that he wrote for the new Synertek SYM-1, "A Digital Clock Program for the SYM-1". The program is a 24 hour clock and has a number of SYM specific subroutine calls and special locations which make it a good introduction for the SYM owner.

Commodore thought they were being pretty smart making the PEEK in BASIC incapable of PEEKing at BASIC itself. Harvey B. Herman was even smarter and shows how he is "Peeking at PET's BASIC". He raises some questions about Commodore's basic strategy.

"KIMBASE" is a major program by Dr. Barry Terman. While the purpose of the program is to convert from almost any number system to any other, its main value to many readers may be in the numerous subroutines which provide support multiplying, dividing, and other functions.

WE'RE STILL NUMBER ONE !

Robert M. Tripp, Editor

It's been a whole year since I sat down to write "We're Number One!" for the first issue of MICRO. Since then a lot has happened within the microprocessor/microcomputer world, and if anything, the position of the 6502 as the leader has been strengthened.

THE 6502 MICROPROCESSOR FAMILY

There have been a couple of major changes in the basic 6500 family of microprocessor products. Most significant has been the emergence of Synertek and Rockwell International as major producers of 6500 type products. While many companies recognized that the 6500 series of products being developed by MOS Technology were in many technical aspects superior to the 8080 and 6800 product lines, they were reluctant to commit to a sole source product manufactured by a relatively small company. Now that Synertek and Rockwell have made major commitments to develop and support the 6500 line, its growth and acceptance should accelerate.

Rockwell and Synertek are not simply second sourcing existing MOS Technology products, but are undertaking a number of significant new 6500 related product developments. Rockwell has introduced the R6500/1 one-chip microcomputer. Synertek is soon to announce a 6551 ACIA. Also in the works by Rockwell and/or Synertek are a 6545 CRT Controller, a 6509 16 bit microprocessor, and a number of other products. It looks as though most development work at MOS Technology has slowed or stopped and that most of their efforts are devoted to supporting the PET and KIM-1 systems.

A searing blast at the 6502 microprocessor which was written by Jack Hemenway and appeared in EDN was very solidly "put down" by articles by several qualified writers which appeared in a later issue.

THE 6502 MICROCOMPUTERS

This has been a very big year for 6502 based systems. Most of the trade talk and magazine articles are about the PET, TRS-80, and the Apple II, and two-out-of-three ain't bad! The Apple II was just becoming available a year ago when MICRO started, and in fact was featured on the first MICRO cover. Since then the growth of the Apple II has been one of the brightest success stories of the year. In a year when many of the original 8080 based companies found themselves in deep trouble, the 6502 based Apple Computer Company flourished. A year ago it was impossible to get a Commodore PET. They had been demonstrated at some computer shows, but were not yet available. Since then they have come on strong. The "grass roots" support for the PET seems very strong, judging from the number of small magazines that have sprung up devoted to the PET.

As our new year starts, there are two major new 6502 system developments. The Synertek SYM-1 is a single board computer which is essentially an upgrade of the KIM-1. It has more RAM, ROM, and I/O than the KIM, plus a much more powerful monitor program, plus a number of other features. It is just becoming available now, and selling for \$269 with 1K RAM, is hoped to do for Syner-

tek what the KIM-1 did for MOS Technology. The AIM 65 is Rockwell's way of announcing its serious entry into the 6502 world. This single board system includes a full typewriter style keyboard, twenty character LED display and a twenty column printer, plus room for 4K RAM, up to 20K ROM, and an extensive 8K monitor. This product is sure to generate a great deal of interest in the 6502 from a variety of users. Both Synertek and Rockwell will be selling an assembler in ROM and an 8K BASIC in ROM by the end of the year.

In addition to these major 6502 microcomputer systems, a number of other smaller manufacturers have introduced 6502 based systems in the past year. The only major drop-out during the year was ECD's MICROMIND. Since this system was never really delivered from production to any customers, its loss was probably of little significance, except to those loyal customers who had their money tied up for a year or so.

6502 SOFTWARE

Whereas a year ago there were only a small handful of programs available for the 6502, there must by now be hundreds of them. Both the PET and the Apple II have generated large markets for 6502 based software, and many stores now have large quantities of programs for sale.

MICRO

We have been very pleased with the growth of MICRO in its first year. The first issue was 28 pages long and went to about 450 subscribers and stores. This issue is twice the size and will immediately go out to about 2000 subscribers and about 1500 more copies will go to the computer stores. A distributorship has been established in Europe to handle the growing interest over there. And, due to popular demand, "The BEST of MICRO" will soon be published so that new subscribers can get the information from the first year of MICRO. Over 3000 copies of each issue have been distributed, many as "back issues" to new subscribers. We are also quite proud of the quality of the articles which have been contributed over the year. We anticipate similar growth during the coming year as the 6502 continues in phenomenal expansion.

Our plans for the coming year include increasing the size of MICRO as required to print all of the worthwhile articles we receive. Our new printing format will permit us some increase in size without requiring an increase in price. If we continue to receive more good stuff than we can print, then we will consider becoming a monthly publication. In order to serve the fast growing European market, we have arranged to have MICRO distributed by L P Enterprises in Britain. This will help keep the cost to 6502 owners in Europe reasonable.

Our success in the coming year depends on your input. We can be no better than the material submitted to us. You have done a great job so far, so keep up the good work.

BREAKER: AN APPLE II DEBUGGING AID

Rick Auricchio
59 Plymouth Ave.
Maplewood, NJ 07040

When debugging an Assembly-language program, one of the easiest tools the programmer can use is the Breakpoint. In its most basic form, the Breakpoint consists of a hardware feature which stops the CPU upon accessing a certain address; a "deluxe" version might even use the Read/Write and Sync (instruction fetch) lines to allow stopping on a particular instruction, the loading of a byte, or the storing of a byte in memory. Since software is often easier to create than hardware (and cheaper for some of us!), a better method might be to implement the Breakpoint with software, making use of the BRK opcode of the 6502 CPU.

A Breakpoint, in practice, is simply a BRK opcode inserted over an existing program instruction. When the user program's execution hits the BRK, a trap to the Monitor (via the IRQ vector \$FFFE/FFFF) will occur. In the APPLE, the Monitor saves the user program's status and registers, then prints the registers and returns control to the keyboard. The difficult part, however, comes when we wish to resume execution of the program: the BRK must be removed and the original instruction replaced, and the registers must be restored prior to continuing execution. If we merely replace the original opcode, however, the BRK will not be there should the program run through that address again.

The answer to this problem is BREAKER: a software routine to manage Breakpoints. What the debugger does is quite simple: it manages the insertion and removal of breakpoints, and it correctly resumes a user program after hitting a breakpoint. The original instruction will be executed automatically when the program is resumed!

Is it Magic?

No, it's not magic, but a way of having the computer remember where the breakpoints are! If the debugger knows where the breakpoints are, then it should also know what the original instruction was. Armed with that information, managing the breakpoints is easy. Here's how the debugger works:

During initialization, BREAKER is "hooked-in" to the APPLE monitor via the Control-Y user command exit, and via the COUT user exit. The control-Y exit is used to process debugger commands, and the COUT exit is used to "steal control" from the Monitor when a BRK occurs.

Breakpoint information is kept in tables: the LOCTAB is a table of 2-byte addresses--it contains the address at which a breakpoint has been placed. The ADTAB is a table of 1-byte low-order address bytes; it is used to locate a Break Table Entry (BTE for short). The BTE is 12 bytes long (only the first 9 are used, but 12 is a reasonably round number) and it contains the following items:

- * Original user-program instruction
- * JMP back to user-program
- * JMP back for relative branch targets

When adding a breakpoint, we must build the BTE correctly, and place the user-program break add-

ress into the LOCTAB. There are eight (8) breakpoints allowed, so that we have a 16-byte LOCTAB, 8-byte ADTAB, and 96 bytes of BTE's.

As the breakpoint is added, the original instruction is copied to the first 3 bytes of the BTE, and it is "padded" with NOP instructions (\$EA) in case it is a 1 or 2-byte instruction. A BRK opcode (\$00) is placed into the user program in place of the original instruction's opcode (other instruction bytes are not altered). The next 3 bytes of the BTE will contain a JMP instruction back to the next user-program instruction.

If the original instruction was a Relative Branch, one more thing must be considered: if we remove the relative branch to the BTE, how will it branch correctly? This problem is solved by installing another JMP instruction into the BTE for a relative branch--back to the Target of the branch, which is computed by adding the original PC of the branch, +2, +offset. This Absolute address will be placed into the JMP at bytes 7-9 of the BTE. The offset which was copied from the original instruction will be changed to \$04 so that it will now branch to that second JMP instruction within the BTE; the JMP will get us to the intended target of the original Relative Branch.

A call to the routine "INSDS2" in the Monitor returns the length and type of an instruction for the "add" function. The opcode is supplied in the AC, and LENGTH & FORMAT are set appropriately by the routine.

Removal of a breakpoint involves simply restoring the original opcode, and clearing the LOCTAB to free this breakpoint's BTE.

Displaying of breakpoints prints the user-program address of a breakpoint, followed by the address of the BTE associated with the breakpoint (the BTE address is useful--its importance will be described later).

When the breakpoint is executed, a BRK occurs and the APPLE Monitor gets control. The monitor will "beep" and print the user program's registers. During printing of the registers, BREAKER will take control via the COUT exit. (Remember, we get control on every character printed - but it's only important when the registers are being printed. That's when we're at a breakpoint). While it has control, BREAKER will grab the user-program's PC and save it (we must subtract 2 because of the action of the BRK instruction). If no breakpoint exists at this PC (we scan LOCTAB), then the Monitor is continued. If a breakpoint does exist here, then the BTE address is set as the "continue PC". In other words, when we continue the user program after the break, we will go to the BTE; the original instruction will now be executed, and we will branch back to the rest of the user program.

Using BREAKER

The first thing to do is to load BREAKER into high memory. It must then be initialized via entry at the start address. This sets up the exits from the Monitor. After a Reset, you must re-initialize via "YcI" to set up the COUT exit

again. Upon entry at the start address, all breakpoints are cleared; after "YcI", they remain in effect.

To add a breakpoint, type: aaaaYcA . (Yc is control-Y). This will add a breakpoint at address 'aaaa' in the user program. A 'beep' indicates an error; you already have a breakpoint at that address. To remove a breakpoint, type: aaaaYcR. This will remove the breakpoint at address 'aaaa' and restore the original opcode. A 'beep' means that there was none there to start with.

Run your user-program via the Monitor's "G" command. Upon hitting a breakpoint, you will get the registers printed, and control will go back to the monitor as it does normally. At this point, all regular Monitor commands are valid, including "YcA", "YcR", and "YcD" for BREAKER.

To continue execution (after looking at stuff maybe modifying some things), type: YcG . This instructs BREAKER to resume execution at the BTE (to execute the original instruction), then to transfer control back to the user program. Do not resume via Monitor "G" command--it won't work properly, since the monitor knows nothing of breakpoints. To display all breakpoints, type: YcD. This will give a display of up to 8 breakpoints, with the address of the associated BTE for each one.

Caveats

Some care must be taken when using BREAKER to debug a program. First, there is the case of BREAKER not being initialized when you run the user program. This isn't a problem when you start, because you'll not be able to use the Yc commands. But if you should hit Reset during testing, you must re-activate via "YcI", otherwise BREAKER won't get control on a breakpoint. If you try a YcG, unpredictable things will happen. If you know that you hit a breakpoint while BREAKER was not active, you can recover. Simply do a "YcI", and then display the breakpoints (YcD). Resume the user-program by issuing a Monitor "G" command to the BTE for the breakpoint that was hit (since BREAKER wasn't around when you hit the breakpoint, you have to manually resume execution at the BTE). Now all is back to normal. You can tell if BREAKER is active by displaying locations \$38 and \$39. If not active, they will contain \$F0 FD.

It's also important to note that any user program which makes use of either the Control-Y or COUT exits can't be debugged with BREAKER. Once these exits are changed, BREAKER won't get control when it's supposed to.

BREAKER DEBUGGER: Routines to Handle up to 8 Breakpoints, for use in Debugging of User Code.

```

**** APPLE-2 MONITOR EQUATES
*
002E      FORMAT      EQU      X'2E'          INSTRUCTION FORMAT
002F      LENGTH      EQU      X'2F'          INSTRUCTION LENGTH
003C      A1L          EQU      X'3C'          WORK AREA
003D      A1H          EQU      X'3D'
003E      A2L          EQU      X'3E'
003F      A2H          EQU      X'3F'
0040      A3L          EQU      X'40'
0041      A3H          EQU      X'41'
*
0036      CSWL         EQU      X'36'          COUT SWITCH WORD
0037      CSWH         EQU      X'37'
*
F88E      INSDS2       EQU      X'F88E'        DISASSEMBLER
F940      PRNTYX        EQU      X'F940'        PRINT Y/X REGS IN HEX
FDDA      PRPYTE        EQU      X'FDDA'        PRINT AC IN HEX
FDED      COUT          EQU      X'FDED'        CHAR OUT
FF65      RESET        EQU      X'FF65'        MONITOR RESET
FF69      MON          EQU      X'FF69'        MONITOR ENTRY
*
* CHANGE 'LOWPAGE' TO LOCATE
* ELSEWHERE IN MEMORY. IT IS
* NOW SET FOR A 32K SYSTEM.
*
0000007D      LOWPAGE   EQU      X'7D'          3 PGS BEFORE END MEMORY
7D00                                ORG      LOWPAGE**8    ORG OUT TO MEMORY TOP
7D00      4C 36 7F      INIT      JMP      INITX          =>INITIALIZATION ENTRY
*
* --- DATA AREAS --- *
*
7D03      00           FW1        DC      0              'FINDPC' WORK BYTE 1
7D04      00           FW2        DC      0              'FINDPC' WORK BYTE 2
7D05      00           PCL        DC      0              'GO' PC LO
7D06      00           PCH        DC      0              'CO' PC HI
*
** SKELETON BREAK-TABLE ENTRY (BTE) **
*
7D07      00           SKEL       DC      0              SKELETON BTE
7D08      EA           NOP        NOP        NOPS FOR PADDING
7D09      EA           NOP        NOP
7D0A      4C 00 00      JMP        0              JUMP BACK INLINE
7D0D      4C           DC          X'4C'          JUMP OPCODE FOR BRANCHES
*

```



```

*
* -- LO ADDRESS OF BTE'S KEPT IN ADTAB -- *
*
7D0E      26      ADTAB      DC      BTE0&255      LO ADDRESS
7D0F      32      DC      BTE1&255
7D10      3E      DC      BTE2&255
7D11      4A      DC      BTE3&255
7D12      56      DC      BTE4&255
7D13      62      DC      BTE5&255
7D14      6E      DC      BTE6&255
7D15      7A      DC      BTE7&255
*
** -- LOCTAB CONTAINS ADDRESS OF USER-PROGRAM INSTRUCTION
*      WHERE WE PLACED THE BREAKPOINT IN THE FIRST PLACE.
*
7D16      LOCTAB      DS      2*8      SPACE FOR 16 PCH/L PAIRS
*
** -- BREAK-TABLE ENTRIES (BTE'S) --- *
*
7D26      BTE0      DS      12      12-BYTES RESERVED
7D32      BTE1      DS      12
7D3E      BTE2      DS      12
7D4A      BTE3      DS      12
7D56      BTE4      DS      12
7D62      BTE5      DS      12
7D6E      BTE6      DS      12
7D7A      BTE7      DS      12      ENOUGH FOR 8 BREAKPOINTS
*
* END OF DATA AREAS
* THE REST IS ROM-ABLE.
*

```

```

*****
*      NAME:      FINDPC
*      PURPOSE:   CHECK IF PC IN FW1/FW2 MATCHES ANY IN LOCTAB
*      RETURNS:   CARRY SET IF YES; XREG=ADTAB INDEX 0-7
*                CARRY CLR IF NOT; XREG=GARBAGE
*      VOLATILE:  DESTROYS AC
*****
7D86      A2 0F      FINDPC      LEXIM      15      BYTE-INDEX TO END OF TABLE
7D88      AD 04 7D      FPC00      LDA      FW2      GET FOR COMPARE
7D8E      ED 16 7D      CMPX      LOCTAB      A PCH MATCH?
7D8E      D0 08      FNE      FPC02      =>NO. TRY NEXT 2-PYTE ENTRY
7D90      AD 03 7D      LDA      FW1      GET PCL NOW
7D93      DD 15 7D      CMPX      LOCTAB-1      A PCL MATCH?
7D96      F0 06      BEQ      FPC04      =>YES! WE HAVE A BREAKPOINT!
7D98      CA      FPC02      DEX      BACK UP ONE
7D99      CA      DEX      AND ANOTHER
7D9A      10 EC      BPL      FPC00      =>DO ENTIRE TABLE SCAN
7D9C      18      CLC      =>DONE; SCAN FAILED
7D9D      60      RTS
*
7D9E      48      FPC04      PHA      HOLD AC
7D9F      8A      TXA      HALVE VALUE IN XREG
7DA0      4A      LSRA      SINCE IT'S 2-BYTE INDEX
7DA1      AA      TAX
7DA2      68      PLA
7DA3      38      SEC      SET 'SUCCESS'
7DA4      60      RTS

```

```

*****
*      NAME:      BREAK
*      PURPOSE:   HANDLE ENTRY AT BRK AND PROCESS BREAKPOINTS
*      NOTE:      THIS ROUTINE GETS ENTERED ON *EVERY* 'COUT'
*                CALL--IT KNOWS ABOUT BRK BECAUSE THE MONITOR'S
*                REGISTERS ARE SETUP TO PRINT USER REG CONTENTS.
*                AFTER PROCESSING IS DONE, IT RESTORES THE MONITOR'S
*                RECS AND RETURNS.
*****
7DA5      E0 FB      BREAK      CPXIM      X'FE'      IS XREG SET FOR EXAMINE-REGS?
7DA7      D0 27      ENE      BRKXX      =>NO GET OUT NOW.

```

7DA9	C9 A0	BRK02	CMPIM	X'A0'	IS AC SETUP CORRECTLY TOO?
7DAB	D0 23		BNE	BRKXX	=>NOPE. FALSE ALARM!
7DAD	A5 3C		LDAZ	AIL	GET USER PCL
7DAF	38		SEC		AND BACK IT UP
7DE0	E9 02		SECIM	2	EY 2 BYTES SINCE
7DB2	8D 03 7D		STA	FW1	BRK BUMPED IT!
7DB5	A5 3D		LDAZ	AIH	GET PCH
7DB7	E9 00		SECIM	0	DO THE CARRY
7DB9	8D 04 7D		STA	FW2	AND SAVE THAT TOO
7DBC	20 86 7D		JSR	FINDPC	A BREAKER OF OURS HERE?
7DEF	90 0B		BCC	BRK04	=>NOPE. WE WON'T HANDLE IT!
7DC1	BD 0E 7D		LDAX	ADTAB	YES; GET BTE ADDRESS THEN
7DC4	8D 05 7D		STA	PCL	AND SET IT AS THE 'GO'
7DC7	A9 7D		LDAIM	LOWPAGE	PC FOR THE 'GO' COMMAND.
7DC9	8D 06 7D		STA	PCH	{OUR PAGE FOR BTE'S}
*					
7DCC	A9 A0	BRK04	LDAIM	X'A0'	SET AC BACK FOR MONITOR
7DCE	A2 FB		LDXIM	X'FB'	AND XREG TOO
7DD0	4C F0 FD	BRKXX	JMP	X'FDF0'	=>NO. RIGHT BACK TO COUT ROUTINE!

 *** PROCESS THE 'GO' COMMAND (RESUME USER EXECUTION) **
 * COMMAND FORMAT: { * Yc G } .

7DD3	AD 05 7D	CMDGO	LDA	PCL	GET RESUME PCL
7DD6	85 3C		STAZ	AIL	AND SETUP FOR MONITOR
7DD8	AD 06 7D		LDA	PCH	TO SIMULATE AN 'XXXX G' COMMAND
7DDB	85 3D		STAZ	AIH	NORMALLY.
7DDD	4C B9 FE		JMP	X'FEB9'	=>SAIL INTO MONITOR'S 'GO'

 ** WE GET CONTROL HERE ON THE CONTROL-Y USER EXIT FROM THE
 * MONITOR (ON KEYINS). ALL COMMANDS ARE SCANNED HERE;
 * CONTROL WILL PASS TO THE APPROPRIATE ROUTINE.

7DE0	A2 FF	KEYIN	LDXIM	X'FF'	CHAR INDEX
7DE2	E8	KEYIN00	INX		SET NEXT CHARACTER
7DE3	BD 00 02		LDAX	X'0200'	GET CHAR FROM KEYIN BUFFER
7DE6	C9 99		CMPIM	X'99'	CONTROL-Y CHARACTER?
7DE8	D0 F8		BNE	KEYIN00	=>NO. KEEP SCANNING
7DEA	E8		INX		BUMP OVER CTL-Y
7DEB	BD 00 02		LDAX	X'0200'	GRAB COMMAND CHARACTER
7DEE	C9 C7		CMPIM	X'C7'	IS IT 'G' (GO) ?

*
 * A BRANCH-TABLE WOULD BE
 * NEATER, BUT IT WOULD
 * TAKE UP MORE CODE FOR
 * THE FEW OPTIONS WE HAVE.
 *

7DF0	F0 E1		BEQ	CMDGO	=>YES.
7DF2	C9 C1		CMPIM	X'C1'	IS IT 'A' (ADD) ?
7DF4	F0 18		BEQ	CMDADD	=>YES.
7DF6	C9 C4		CMPIM	X'C4'	IS IT 'D' (DISPLAY) ?
7DF8	F0 0B		BEQ	XXDISP	=>YES.
7DFA	C9 D2		CMPIM	X'D2'	IS IT 'P' (REMOVE) ?
7DFC	F0 0A		BEQ	XXREMOVE	=>YES.
7DFE	C9 C9		CMPIM	X'C9'	IS IT 'I' (INIT) ?
7E00	F0 09		BEQ	XXINIT	=>YES.
7E02	4C 65 FF	BADCMD	JMP	RESET	NOTHING; IGNORE IT!
*					
7E05	4C A8 7E	XXDISP	JMP	CMDDISP	EXTENDED BRANCH
7E08	4C 08 7F	XXREMOVE	JMP	CMDREMOV	EXTENDED BRANCH
7E0B	4C 4F 7F	XXINIT	JMP	CMDINIT	EXTENDED BRANCH

```

*****
**      PROCESS THE 'ADD' COMMAND..ADD A BREAKPOINT AT
**      LOCATION SPECIFIED IN COMMAND
*      COMMAND FORMAT: ( * aaaa Yc A ) .
*****
7E0E      A0 00      CMDADD      LDYIM      0      CHECK OPCODE FIRST
7E10      E1 3E      LDAIY      A2L      OP AT AAAA A BRK ALREADY?
7E12      F0 EE      BEQ      BADCMD      =>YES. ILLEGAL!

*
* --- SCAN LOCTAB FOR AN AVAILABLE BTE TO USE --- *
*
7E14      A2 0F      ADD00      LDXIM      15      BYTE INDEX TO LOCTAB END
7E16      ED 16 7D      LDAX      LOCTAB      GET A FYTE
7E19      D0 05      BNE      ADD02      =>IN USE
7E1P      ED 15 7D      LDAX      LOCTAB-1      GET HI HALF
7E1E      F0 06      BEQ      ADD04      => BOTH ZERO; USE IT!
7E20      CA      ADD02      DEX      MOVE BACK TO
7E21      CA      DEX      NEXT LOCTAB ENTRY
7E22      10 F2      BPL      ADD00      AND KEEP TRYING!
7E24      30 DC      BMI      BADCMD      =>DONE? ALL FULL! REJECT IT.

*
7E26      A5 3E      ADD04      LDAZ      A2L      GET aaaa VALUE
7E28      9D 15 7D      STAX      LOCTAB-1      SAVE LO HALF
7E2P      8D 0F 7D      STA      SKEL+4      STUFF LO ADDR INTO BTE
7E2E      A5 3F      LDAZ      A2H      GET aaaa VALUE
7E30      9D 16 7D      STAX      LOCTAB      SAVE HI HALF
7E33      8D 0C 7D      STA      SKEL+5      STUFF HI ADDR INTO BTE
7E36      8A      TXA      GRAB INDEX FOR LOCTAB
7E37      4A      LSRA      MAKE ADTAB INDEX
7E38      AA      TAX      AND STUFF BACK INTO XREF
7E39      A9 7D      LDAIM      LOWPAGE      BTE'S HI ADDRESS VALUE
7E3E      85 41      STAZ      A3H      HOLD IN WORK AREA
7E3D      ED 0E 7D      LDAX      ADTAB      GET BTE LO ADDR FROM ADTAB
7E40      85 40      STAZ      A3L      SAVE IN WORK AREA
7E42      A0 07      LDYIM      7      7-PYTE MOVE FOR SKEL BTE
7E44      B9 07 7D      LDAY      SKEL      GET SKEL FYTE
7E47      91 40      STAIY      A3L      MOVE TO BTE
7E49      88      DEY      SET NEXT
7E4A      10 F8      BPL      ADD06      => MOVE ENTIRE SKELETON
7E4C      C8      INY
7E4D      E1 3E      LDAIY      A2L      GET ORIGINAL OPCODE
7E4F      91 40      STAIY      A3L      INTO BTE
7E51      20 8E F8      JSR      INSDS2      INSDS2 (TO DISASSEMBLE)
7E54      A9 00      LDAIM      0      SET BRK OPCODE
7E56      91 3E      STAIY      A2L      OVER ORIGINAL OPCODE
7E58      A5 2F      LDAZ      LENGTH      GET INSTRUCTION LENGTH
7E5A      38      SEC

*
* --- SET UP JMP TO NEXT INST. IN THE BTE --- *
*
7E5E      A0 04      LDYIM      4
7E5D      71 40      ADCIY      A3L      ADD TO PC FOR DESTINATION
7E5F      91 40      STAIY      A3L      STUFF INTO BTE
7E61      C8      INY
7E62      E1 40      LDAIY      A3L      RUN UP THE CARRY
7E64      69 00      ADCIM      0      RIGHT HERE

```

```

*****
*      DISPLAY ALL ACTIVE BREAKPOINTS
*      COMMAND FORMAT: (* Yc D )
*****
7E48      A2 0F      CMDDISP      LDYIM      15      INDEX TO LOCTAB END
7E4A      ED 16 7D      DISPO0      LDAX      LOCTAB      GET A FYTE
7E4E      D0 0F      BNE      DISPO4      =>IN USE
7E4F      ED 15 7D      LDAX      LOCTAB-1      TRY BOTH BYTES TO BE SURE
7E52      D0 06      BNE      DISPO4      => DEFINITELY IN USE.
7E54      CA      DISPNXT      DEX      SET NEXT ENTRY
7E55      CA      DEX      IN LOCTAB
7E56      10 F2      BPL      DISPO0      => NOPE TO GO
7E58      30 C7      BMI      CMDBRET      =>DONE; EXIT TO MONITOR

*

```

7EBA	8A	DISP04	TXA		GET INDEX
7EBB	48		PHA		SAVE IT
7EBC	BC 16 7D		LDYX	LOCTAB	GET SUBJECT-INST PCH
7EBF	BD 15 7D		LDAX	LOCTAB-1	AND ITS PCL
7EC2	84 3B		STYZ	X'3B'	SET UP PCH/PCL FOR
7EC4	85 3A		STAZ	X'3A'	DISASSEMBLER...
7EC6	AA		TAX		
7EC7	20 40 F9		JSR	PRNTYX	PRINT Y,X BYTES IN HEX
7ECA	A9 A0		LDAIM	X'A0'	PRINT ONE
7ECC	20 ED FD		JSR	COUT	SPACE HERE
7ECF	68		PLA		RESTORE INDEX
7ED0	48		PHA		
7ED1	4A		LSRA		CONVERT TO ADTAB INEX
7ED2	AA		TAX		
7ED3	A9 BC		LDAIM	X'BC'	'<' CHARACTER
7ED5	20 ED FD		JSR	COUT	PRINT IT
7ED8	A9 7D		LDAIM	LOWPAGE	BTE HI ADDRESS
7EDA	85 3F		STAZ	A2H	SET INDIRECT POINTER
7EDC	20 DA FD		JSR	PRBYTE	PRINT HEX BYTE
7EDF	BD 0E 7D		LDAX	ADTAB	GET BTE LO ADDR
7EE2	85 3E		STAZ	A2L	SET INDIRECT POINTER
7EE4	20 DA FD		JSR	PREYTE	PRINT BTE FULL ADDRESS
7EE7	A9 BE		LDAIM	X'BE'	'>' CHARACTER
7EE9	20 ED FD		JSR	COUT	PRINT IT

*
 * --- DISASSEMBLE THE ORIGINAL INSTRUCTION. PICK UP
 * ORIGINAL OPCODE FROM BTE, ORIGINAL ADDRESS
 * FIELD FROM USER PROGRAM LOCATION.
 *

7EEC	A9 A0		LDAIM	X'A0'	PRINT ONE
7EEE	20 ED FD		JSR	COUT	SPACE HERE
7EF1	A0 00		LDYIM	0	INDEX
7EF3	B1 3E		LDAIY	A2L	GET OPCODE FROM PTE
7EF5	20 DA FD		JSR	PREYTE	PRINT OPCODE
7EF8	B1 3E		LDAIY	A2L	GET OPCODE FROM BTE
7EFA	20 8E F8		JSR	INSDS2	AND GET FORMAT/LENGTH
7EFD	20 04 7F		JSR	JSRKLUGE	SNEAK INTO INSDSP @ F8D9
7F00	68		PLA		
7F01	AA		TAX		RESTORE LOCTAB INDEX
7F02	10 E0		BPL	DISPNXT	=> DISPLAY THE REST!

*
 *-----
 * KLUGE ENTRY INTO SUBROUTINE
 * WHICH FORCES JSR PRIOR TO
 * A PHA INSTRUCTION. WE HAVE
 * TO JSR TO THIS JMP!
 *

7F04	48		JSRKLUGE	PHA	PUSH MNEMONIC INDEX
7F05	4C D9 F8		JMP	X'F8D9'	CONTINUE WITH INSTDSF

***** END OF KLUGE! *****

 * REMOVE A BREAKPOINT AT LOCATION aaaa
 * COMMAND FORMAT: (aaaa YC R)

7F08	A5 3E	CMDREMOV	LDAX	A2L	GET ADDRESS LC
7F0A	8D 03 7D		STA	FW1	HOLD IT FOR FINDPC
7F0D	A5 3F		LDAX	A2H	GET ADDRESS HI
7F0F	8D 04 7D		STA	FW2	
7F12	20 86 7D		JSR	FINDPC	A BREAKPOINT HERE?
7F15	B0 03		ECS	REMOV02	=>YES
7F17	4C 65 FF		JMP	RESET	=>NO: BELL FOR YOU!
*					
7F1A	ED 0E 7D	REMOV02	LDAX	ADTAB	GET THE LOCTAB ENTRY
7F1D	85 40		STAZ	A3L	HOLD IT
7F1F	8A		TXA		NOW CREATE LOCTAB INDEX
7F20	0A		ASLA		
7F21	AA		TAX		
7F22	A9 00		LDAIM	0	CLEAR OUT THE
7F24	A8		TAY		APPROPRIATE
7F25	9D 16 7D		STAX	LOCTAB	LOCTAB ENTRY
7F28	9D 17 7D		STAX	LOCTAB+1	FOR THIS ENTRY

7F2E	A9 7D	LDAIM	LOWPAGE	HI ADDR FOR ETE
7F2D	85 41	STAZ	A3H	HOLD FOR ADDRESSING
7F2F	E1 40	LDAIY	A3L	GET OPCODE OUT OF ETE
7F31	91 3E	STAIY	A2L	AND PUT BACK INTO ORIGINAL INST
7F33	4C 69 FF	JMP	MON	=>ALL DONE.

```

*****
*      INITIALIZATION CODE. ENTERED AT START ADER TO INITIALIZE.
*      IT CLEARS LOCTAB, SETS UP THE Yc AND 'COUT' EXITS.
*
*      AFTER EVERY 'RESET', MUST RESETUP WITH * Yc I .
*****

```

7F36	A9 4C	INITX	LDAIM	X'4C'	JMP OPCODE
7F38	8D F8 03		STA	X'3F8'	STUFF IN Yc EXIT LOC
7F3B	A9 7D		LDAIM	KEYIN/256	KEYIN: HI ADDRESS
7F3D	8D FA 03		STA	X'3FA'	STUFF INTO JMP
7F40	A9 E0		LDAIM	KEYIN&X'FF'	KEYIN: LO ADDRESS
7F42	8D F9 03		STA	X'3F9'	STUFF INTO JMP ADDRESS
7F45	A9 00		LDAIM	0	
7F47	A2 0F		LDXIM	15	INDEX TO LOCTAB END
7F49	9D 16 7D	INIT00	STAX	LOCTAB	CLEAR IT OUT
7F4C	CA		DEX		SO THERE ARE
7F4D	10 FA		BFL	INIT00	NO BREAKPOINTS

*
* ---- ENTER HERE AFTER HITTING 'RESET' KEY, PLEASE --- *
*

7F4F	A9 A5	CMDINIT	LDAIM	BREAK&255	BREAK: LO ADDRESS
7F51	85 36		STAZ	CSWL	STUFF INTO 'COUT' EXIT HOOK
7F53	A9 7D		LDAIM	BREAK/256	BREAK: HI ADDRESS
7F55	85 37		STAZ	CSWH	STUFF INTO 'COUT' EXIT HOOK
7F57	4C 69 FF		JMP	MON	INIT DONE; BACK TO MON.

END

Table 1 - BREAKER Command Summary

Listing 1 - BREAKER Program for Apple II

Command	Function	Notes on how to read the assembler listing:
aaaa Yc A	Add breakpoint at location aaaa. Won't allow you to add one over an already existing breakpoint. Maximum of 8 breakpoints allowed.	A few of the syntax expressions allowed by my time-sharing cross assembler may appear cryptic. Here's a key to their meanings:
Yc D	Display all breakpoints.	1. All HEX numbers appear as X' rather than \$ expressions.
Yc I	Initialize after RESET key. Just sets up 'COUT' exit again without resetting any breakpoints.	2. The ampersand (&) means logical "AND" thus: KEYIN&X'FF'
aaaa Yc R	Remove breakpoint from location aaaa. Restores original opcode.	resolves to the low-order 8 bits of the KEYIN address.

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MOS 16K RAM FOR THE APPLE II

Allen Watson III
430 Lakeview Way
Redwood City, CA 94062

MOS 16K dynamic RAM is getting cheaper. At the time of this writing, one mail-order house is offering 16K bytes of RAM (eight devices) for \$120. Apple II owners can now enhance their systems for less than the Apple dealers' price. However, there is a potential drawback to the purchase of your own 16K RAM chips: speed. You may wonder why, since the Apple's 6502 CPU is running at only about 1 MHz, but things aren't quite that simple.

To begin with, the Apple II continually refreshes its video display and dynamic RAM. It does this by sharing every cycle between the CPU and the refresh circuitry, a half-cycle for each. This means that the RAM is being accessed at a 2 MHz rate.

That doesn't sound too fast, with the slowest 16K parts rated at 300ns access time; but you have to remember that the RAM chips are 16-pin parts by virtue of a multiplexed address bus. There are two address-strobe signals during each memory access cycle, and the access-time specification will be met only if the delay between these strobe signals is within specified limits. In the Apple II this delay is 140ns, which is too long. Furthermore, the Apple II timing doesn't allow long enough RAS precharge or row-address hold time for the slow parts. Judging by the spec sheets, 200ns parts are preferable to 250ns parts, and 300ns parts shouldn't be used at all. In my Apple, 300ns parts caused a zero to turn into a one once in a while.

Many mail-order houses do not mention device speeds in their ads. The best thing to do is to deal only with those suppliers who specify speeds, but for those who didn't, the table below shows the codes used by some 16K dynamic RAM manufacturers to indicate the speeds of their devices. Good luck, and caveat emptor!

SPEED CODES USED BY 16K DYNAMIC RAM MANUFACTURERS

Manufacturer	Part No.	Access Time (ns)			
		150	200	250	300
A M D	9016	-F	-E	-D	-C
Fairchild	F16K	-2	-3	-4	-5
Intel	2117	-2	-3	-4	
MOSTEK	4116	-2	-3	-4	
Motorola	MCM4116C	-15	-20	-25	-30
National	MM5290	-2	-3	-4	
N E C	μ D416	-3	-2	-1	
T I	4116	-15	-20	-25	
Zilog	Z6166	-2	-3	-4	

IMPROVED STAR BATTLE SOUND EFFECTS

William M. Shryock, Jr.
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Williston, ND 58801

```
10 POKE 0,160: POKE 1,1: POKE
   2,162: POKE 3,0: POKE 4,138
   : POKE 5,24: POKE 6,233: POKE
   7,1: POKE 8,208: POKE 9,252
   : POKE 10,141
20 POKE 11,48: POKE 12,192: POKE
   13,232: POKE 14,224: POKE 15
   ,150: POKE 16,208: POKE 17,
   242: POKE 18,136: POKE 19,208
   : POKE 20,237: POKE 21,96
30 CALL -936: VTAB 12: TAB 9: PRINT
   "STAR BATTLE SOUND EFFECTS"

40 SHOTS= RND (15)+1
50 LENGTH= RND (11)*10+120
60 POKE 1,SHOTS: POKE 15,LENGTH:
   CALL 0
70 FOR DELAY=1 TO RND (1000): NEXT
   DELAY
80 GOTO 40
```

This version can be used in low res. programs without having to reset HIMEM. Also it can all be loaded from BASIC.

PET UPDATE

Gary A. Creighton
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I am writing this article because I'm tired of seeing the same rehash of pseudo-facts being repeated about the PET. If I read one more time about the small keyboard or the RND function not working correctly...! As you will see, the 2001 has an extremely well designed Interpreter which can be used effectively as subroutines either from the SYS command, or the USR command. Parameter passing will be revealed as an easy operation, and returning USR with a value is just as simple. The RND function may be substituted with a twelve byte USR program to make it completely random and non-repeating (as it stands, it repeats every 24084 times through) and I will show the use of negative arguments. Unfortunately, RND(0) was apparently a mis-calculation on Microsoft's part. They figured that ROM empty locations would turn out to be more random than the end product shows. They load non-existent memory locations into the RND store area (218-222) thus causing a resulting RND value which fluctuates between a few different values. When ROM is finally installed in that area (36932) the RND(0) will have the dubious quality of being some fixed number.

RND FUNCTION USE

The RND function may be set at any time to execute a known series of RND #'s by using a known negative argument just before RND with a positive one. The ability to have available a known list of random numbers is very important in a lot of sciences.

```
10 R=RND(-1)
20 FOR X=1 TO 5
30 PRINT INT(1000*RND(1)+1),
40 NEXT X
```

Gives the sequence: 736, 355, 748, 166,629

Since RND(-low#) gives such a small value, use a negative argument in the range (-1 E10 to -1 E30) if you need one repeatable RND number with a useful value, e.g., RND(-1 E20)= .811675238.

Concerning the true random nature of RND and it's ability to act randomly at all times; time must be combined with RND. This is possible with a RANDOMIZE subroutine or faster still, redoing RND(+) with a USR routine.

```
10000 REM (RANDOMIZE)
10010 R1=PEEK(514) : R2=PEEK(517)
10020 POKE 220, R1 : POKE 221, R2
10030 RETURN
```

This routine may be used at program initialization and as the program halts for an INPUT. It will start a new sequence of RND numbers whenever called.

When the computer does a sequence without intervention, the following USR program is suggested which will return a truly random number quickly; without repeating.

```
10 REM (TRUE RND USING USR FUNCTION)
20 POKE 134,214 : POKE 135,31 : CLR
30 FOR X=8150 TO 8165
40 READ BYTE : POKE X, BYTE
```

```
50 NEXT X
60 DATA 173,2,2,133,220,173,5,2,133,221,76
65 DATA 69,223,0,0,0
70 POKE 1,214 : POKE 2,31
```

MACHINE LANGUAGE STORING IN BASIC

When using machine language, always precede storing by setting up BASIC's upper boundary. This is done by:

```
POKE 134, ITEM : POKE 135, PAGE : CLR
e.g. POKE 134, 0 : POKE 135, 25 : CLR
sets upper boundary to 6400 and BASIC use will be confined to 1024 to 6399 unless reset or turned off.
```

You can use the following program for storing decimal. Changing INDEX to 10000 to appropriate position and typing in DATA lines in 100 to 9997.

```
0 REM ("MACHINE STORE")
1 REM WRITTEN BY GARY A. CREIGHTON, JULY 78
2 REM ( SET INDEX=ORIGIN IN LINE 10000 )
3:
15 REM FIX UPPER STRING BOUNDARY
20 GOSUB 10000
25 X=INDEX / 256
30 PAGE=INT(X)
35 ITEM=(X-PAGE)* 256
40 POKE 134, ITEM
45 POKE 135, PAGE
50 CLR
55 :
60 REM LOAD MACHINE LANGUAGE
65 GOSUB 10000 : LOC=INDEX
70 READ BYTE : IF BYTE<0 THEN END
75 POKE LOC, BYTE
80 LOC=LOC+1 : GOTO 70
85 :
90 REM MACHINE LANGUAGE DATA
100 DATA
:
:
9997 DATA
9998 DATA 0,0,0,-1
9999 :
10000 INDEX=(START OF MACHINE LANGUAGE)
10010 RETURN
```

USR PARAMETER PASSING

The following are parameter passing rules for the USR function and should be added to the "MACHINE STORE" program.

```
0 REM ("USR(0 TO 255)")
46 POKE 1, ITEM
48 POKE 2, PAGE
100 REM (USR INPUT 0-255; OUTPUT 0-255)
110 DATA 32,121,214 : REM JSR 54905
120 DATA (Your program using input value)
:
:
5000 DATA (Setup output value in Accum.)
5010 DATA 76,245,214 : REM JMP 55029
10000 INDEX 6400
```



```

OR
0 REM ("USR(0 TO 65535)")
46 POKE 1, ITEM
48 POKE 2, PAGE
100 REM (USR INPUT 0-65535;OUTPUT 0-65535)
110 DATA 32,208,214 : REM JSR 54992
    (Note: Check if 0-65535. RTS with:
        Y and M(8)= ITEM
        A and M(9)= PAGE
120 DATA (Your program using 2 byte passed
    value)
.
.
5000 DATA (Setup output vlaue ITEM in Y;
    PAGE in A)
5010 DATA 132,178 : REM STYZ 178
5020 DATA 133,177 : REM STAZ 177
5030 DATA 162,144 : REM LDXIM 144
5040 DATA 56 : REM SEC
5050 DATA 76,27,219 : REM JMP 56091
    (Setup output value and RTS)

```

The input parameter may be any complex expression and you can of course:

input 0-255 and output 0-65535, or
input 0-65535 and output 0-255.

SAVE MACHINE LANGUAGE AND LOAD DIRECTLY

The reason for the 0,0,0 at the end of the preceding machine language programs is that the saving routine described next SAVES machine language until 0,0,0 or an ERROR is printed. After it has been saved in this way, it may be LOADED and VERIFIED with little effort.

Add to "MACHINE STORE" program (all assembly is in decimal).

```

0 REM ("SAVEM")
100 REM ERAM=31 (or last page of RAM on your PET)
110 DATA 32,200,0 : REM JSR 200 check if : or end of line
120 DATA 208,3 : REM BNE OVER
130 DATA 76,158,246 : REM JMP 63134 jump 'SAVE' if SYS 8000 only
OVER 140 DATA 32,17,206 : REM JSR 52753 check if ','
150 DATA 32,164,204 : REM JSR 52388 analyze arithmetical argument
160 DATA 32,208,214 : REM JSR 54992 check if 0-65535
170 DATA 132,247 : REM SYTZ 247 'save from' item
180 DATA 133,248 : REM STAZ 248 'save from' page
190 DATA 170 : REM TAX
200 DATA 152 : REM TYA
210 DATA 208,1 : REM BNE OVR2
OVR2 220 DATA 202 : REM DEX
230 DATA 136 : REM DEY back up 1
240 DATA 132,80 : REM STYZ 80 initialize CHK pointer item
250 DATA 134,81 : REM STXZ 81 initialize CHK pointer page
260 DATA 169,173 : REM LDAIM 173
270 DATA 133,79 : REM STAZ 79 LDA instruction in 0079
280 DATA 169,96 : REM LDAIM 96
290 DATA 133,82 : REM STAZ 82 RTS instruction in 82
300 DATA 32,200,0 : REM JSR 200
310 DATA 201,44 : REM CMPIM 44 check if ',' before filename
320 DATA 208,3 : REM BNE OVR3
OVR3 330 DATA 32,194,0 : REM JSR 194 move code pointer over ','
AGAIN 340 DATA 32,51,244 : REM JSR 62515 get options for "SAVE"
350 DATA 230,80 : REM INCZ 80
360 DATA 208,2 : REM BNE OVR4
OVR4 370 DATA 230,81 : REM INCZ 81 add 1 to CHK pointer
380 DATA 32,79,0 : REM JSR 79 look at next CHK code
390 DATA 208,27 : REM BNE CHEND
400 DATA 160,1 : REM LDYIM 1 check for 0,0,0
410 DATA 177,80 : REM LDAIY 80
420 DATA 208,21 : REM BNE CHEND
430 DATA 200 : REM INY
440 DATA 177,80 : REM LDAIY 80
450 DATA 208,16 : REM BNE CHEND
460 DATA : REM CLC
470 DATA 165,80 : REM LDAZ 80
480 DATA 105,4 : REM ADCIM 4
490 DATA 13 : REM CLC
460 DATA 24 : REM CLC
470 DATA 165,80 : REM LDAZ 80
480 DATA 105,4 : REM ADCIM 4
490 DATA 133,299 : REM STAZ 229 'save to' item
500 DATA 165,81 : REM LDAZ 81
510 DATA 105,0 : REM ADCIM 0
520 DATA 133,230 : REM STAZ 230 'save to' page
530 DATA 76,177,246 : REM JMP 63153 complete 'SAVE'

```

```

CHEND 540 DATA 165,81      : REM LDAZ 81
      550 DATA 201,31      : REM CMPIM ERAM
      560 DATA 240,10      : REM BEQ CHKNF check: 'not found' if last
      570 DATA 144,210     : REM BCC AGAIN look at next if less than
      580 DATA 32,184,31   : REM JSR END
      590 DATA 162,85      : REM LDXIM 85
      600 DATA 76,108,195  : REM JMP 70028 ("?END) NOT FOUND ERROR"
CHKNF 610 DATA 165,80      : REM LDAZ 80
      620 DATA 201,253     : REM CMPIM 253
      630 DATA 144,196     : REM BCC AGAIN again if enough room
      640 DATA 32,184,31   : REM JRS END
      650 DATA 160,40      : REM LDYIM 40
      660 DATA 76,133,245  : REM JMP 62853 ("?END) NOT FOUND ERROR"
END    670 DATA 169,13     : REM LDAIM 13
      680 DATA 32,234,227  : REM JSR 58346
      690 DATA 169,63      : REM LDAIM 63
      700 DATA 32,234,227  : REM JSR 58346
      710 DATA 169,69      : REM LDAIM 69
      720 DATA 32,234,227  : REM JSR 58346
      730 DATA 169,78      : REM LDAIM 78
      740 DATA 32,234,227  : REM JSR 58346
      750 DATA 169,68      : REM LDAIM 68
      760 DATA 32,234,227  : REM JSR 58346 "?END"
      770 DATA 96          : REM RTS
      780 REM (FORMAT: SYS 8000,INDEX,"FILENAME",DEVICE#,I/O OPTION)

```

After typing and saving normally, type RUN when READY. Save "SAVEM" using itself to save itself by typing:

SYS 8000,8000, "SAVE(SYS 8000)"

when READY., REWIND TAPE #1 and type:

VERIFY "SAVE(SYS 8000)"

Loading machine language before BASIC program:

```

LOAD "machine language name"
NEW
A=PEEK(247) :B=PEEK(248)
POKE 134,A :POKE 135,B
POKE 1,A :POKE 2,B (only if USR, not SYS)
CLR

```

Then LOAD BASIC Program.

Loading machine language from BASIC program:

MACHINE LANGUAGE LOAD PROCEDURE

After SAVEing machine language, you have the capability of LOADing directly if you follow these rules.

```

0 IF OK THEN RUN 6
1 OK=-1 : PRINT "PRESS REWIND ON TAPE #1"
2 WAIT 519,4,4 : REM wait til stop if play down but not motor
3 WAIT 59411,8,8 : REM wait til key on cassette pushed
4 WAIT 59411,8 : REM wait til stop on cassette pushed
5 LOAD "machine language name"
6 A=PEEK(247) : B=PEEK(248)
7 POKE 134,A : POKE 135,B
8 POKE 1,A : POKE 2,B : REM (only if USR, not SYS)
9 CLR
10 REM (BEGIN BASIC PROGRAM, MACHINE LANGUAGE LOADED)

```

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6502 INTERFACING FOR BEGINNERS; THE CONTROL SIGNALS

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By now your breadboard should look like a rat's nest so we shall add just a few more wires. So far you have used several decoding chips to produce device select pulses (also called chip selects, port selects, etc.) These pulses activate a particular I/O port, memory chip, PIA device, interval timer or another microcomputer component. Almost all of these components must "know" more than that they have been addressed. They must know if the microprocessor is going to READ data from them or WRITE to them. The R/W control line coming from the R/W pin on the 6502 provides this information. It is at logic 1 for a READ (typically LDA XXXX) and at logic 0 for a WRITE (typically STA XXXX).

If you have ever tried to wrap your mind around timing diagrams for microcomputer systems you soon realize that system timing is also important. Suppose that a memory chip is selected by a device select pulse. A 21L02 chip, after being selected, must decode the lowest 10 address lines itself to decide which of its 1024 flip-flops will become the output data. This takes time, so the data at the output pin is not ready instantaneously. The 6502 simply waits for a specified amount of time, and at the end of this period it reads the information on the data bus. If the access time of the chip is too long, the 6502 will read garbage; otherwise it will get valid data.

Likewise, during a WRITE cycle, the microprocessor brings the R/W line to logic 0, selects the device which is to receive the data, and at the end of a cycle it signals the device to read the data which the 6502 has put on the data bus. The signal which successfully concludes both a READ and a WRITE instruction is the so-called phase-two clock signal symbolized by ϕ_2 . In particular, it is the trailing edge (positive to zero transition) of this signal which is used.

All the timing for the microcomputer is done by the crystal oscillator on the microcomputer board and the clock circuitry on the microprocessor itself. A clock frequency of 1 MHz produces a machine cycle of 1 microsecond in duration. Near the beginning of the cycle the address lines change to select the device which was addressed, and the R/W goes to logic 1 or logic 0 depending on whether a READ or a WRITE was requested. If a READ was requested, some device in the system responds by putting data on the data bus. Typically this happens during the second half of the cycle when ϕ_2 is at logic 1. Finally, at the end of the cycle, but before the address lines or the R/W line have changed, ϕ_2 changes from logic 1 to logic 0, clocking the data into the 6502. The same kinds of things happen during a WRITE cycle, except that now the external device uses the trailing edge of the ϕ_2 signal to clock the data, while the 6502 puts the data on the bus at a slightly earlier time in the cycle. For details refer to the 6502 HARDWARE MANUAL.

The circuits you have built so far, together with a few more chips, will demonstrate the effect of the control signals. Refer to Figure 1 of the last installment of this column (MICRO, Issue 6, p. 30), and to Figure 1 of this issue. You will see the LS145 and the LS138 have not been changed too much, in fact all of the connections to the LS145 should stay the same. The device select pulse from the LS145 goes to G2A

as before, but another signal goes to G2B in the new Figure 1. For the moment disregard the lower LS138 and LS367 in Figure 1 of this issue. The new signal to G2B of the LS138 is our WRITE signal. It is produced by NANDING the R/W signal with ϕ_2 and it is an active-low signal. On the KIM-1 it is called RAM-R/W and is available on the expansion connector. Most other 6502 systems will very likely also have a RAM-R/W signal.

Its effect in Figure 1 is to inhibit the device select pulse from the LS138 whenever the R/W line is high (during all READ instructions), but to allow the device select pulse to occur when the R/W line is low and ϕ_2 is high. Thus, the top LS138 in Figure 1 selects output ports only, and the device select pulse from it terminates on the trailing edge of the ϕ_2 , producing a logic 0 to logic 1 transition simultaneously (almost) with ϕ_2 . This pulse is inverted by the LS04. Consequently, a WRITE instruction produces a positive pulse at the G inputs of the LS75 whose duration is about 1/2 microsecond and whose trailing edge coincides with ϕ_2 .

The 74LS75 is a 4-bit bistable latch whose Q outputs follow the D (data) inputs only when the G inputs are at logic 1, in other words during the device select pulse from the LS04 inverter. The trailing edge of this pulse latches the Q outputs to the value of the D inputs during the device select pulse. If you had a great deal of trouble following this, you may want to check the reverse side of this page to make sure there is nothing valuable on it and then destroy this by burning or shredding! Otherwise proceed to the experiment below.

Connect the circuit shown in Figure 1, omitting for the time being the lower LS138 and the LS367. You can also omit the connection of address line A3 to G1 on the top LS138 if G1 is connected to +5V as was indicated in the last issue. In other words, simply add the LS04 and the LS75 to your circuit of the last issue. The RAM-R/W signal must also be generated if your 6502 board does not have one. Simply use one inverter on the LS04 to invert the R/W signal to R/W, then NAND it with the ϕ_2 , and run the output of the NAND gate to the G2B pin on the LS138.

The address of the device is 800F if the connections are made as shown in the figure. If other pins on either the LS145 and/or the LS138 are changed the address will be different. The switches shown connected to the D inputs may be implemented with a DIP switch or jumper wires. An open switch corresponds to a logic 1 while a closed switch is logic 0. Set the 4 switches to any combination then load and run the following program:

```
0200 8D 0F 80      STA DSF.
```

The LEDs should indicate the state of the switches. If you add the statements

```
0203 4C 00 02      JMP START
```

then you should be able to change the switches and the LEDs will follow the switches. Try substituting an AD 0F 80 (LDA DSF) for the 8D 0F 80 instruction. Nothing should happen, even though the same address is being selected, because on LDA instruction the R/W line is high, inhibiting the LS138 from producing a device select. Fin-

ally, connect the data lines D0-3 from the 6502 to the D-inputs of the LS75, making very sure that the LS145 is de-selecting other locations. On the KIM-1 this means that pin 1 of the LS145 is connected to pin K on the application connector and pin 9 of the LS 145 is connected to pin J. The appropriate pull-up resistors must also be added. With the data lines connected run the following program:

```
0200 A9 04 LDAIM $04
0202 8D 0F 80 STA DSF.
```

Play around with different numbers in LDAIM instruction and explain your results. If nothing seems to make sense, it may be that your data lines need to be buffered, a topic we will take up next issue. If your results make sense you will have discovered that we have configured a 4-bit output port whose address is 800F. Adding another LS75 to connect to data lines D4-D7 and whose G connections also go to the output of the LS04 will give an 8-bit output port. Seven other output ports, addresses 8008 through 800E, could be added using the other device select signals from the LS138, LS04 inverters, and LS75 latches.

If you want to make an input port wire the circuit for the lower LS138 in Figure 1. If you

don't have much more room on your circuit board you might want to simply reconnect the upper LS138 to become the lower LS138. A couple of connections do the trick. Set the switches to anything you like and run the program below.

KIM-1 users should see the hex equivalent of the switch settings appear in the right-most digit on the display. Owners of other systems can omit the last two lines of the program, stop it, and examine the location 00F9 to see that the lowest four bits agree with the switch settings. Experiment with other switch settings to make sure that everything is operating correctly.

The completed circuit of Figure 1 gives one 4-bit output port (provided the data lines are connected to the D inputs of the LS 75) and one 4-bit input port, addresses 800F and 8007 respectively. These two ports are easily expanded (two more chips) to become 8-bit ports. Likewise the circuit of Figure 1 could be expanded to give a total of eight 8-bit input ports and eight 8-bit output ports.

Next issue we will look at a slightly different input port, and we will look in more detail into three-state devices and the data bus. You may want to keep your circuit together until then.

0200 AD 07 80	START	LDA DS7	Read input port data
0203 85 F9		STA DISP	and store it in location 00F9.
0205 20 1F 1F		JSR SCANDS	Jump to KIM display subroutine.
0208 4C 00 02		JMP START	Repeat program.

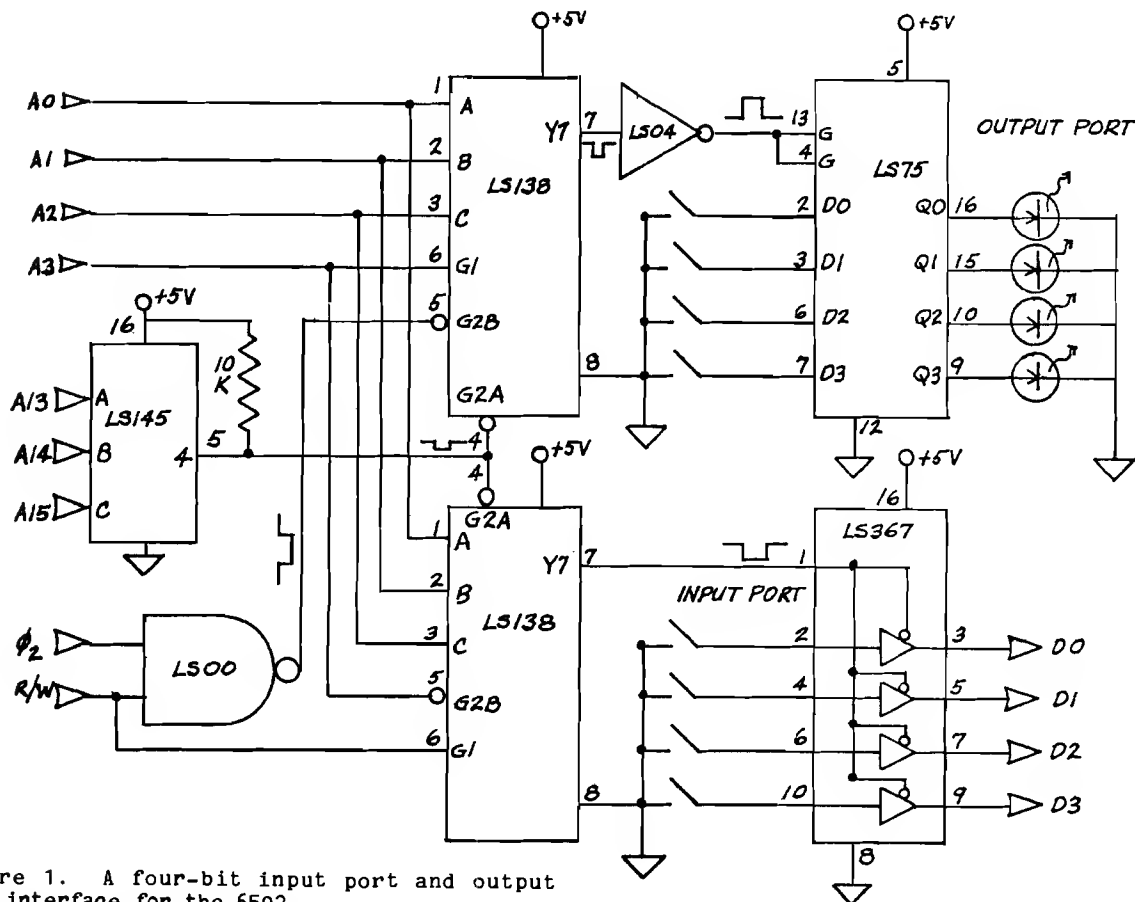


Figure 1. A four-bit input port and output port interface for the 6502.

650X OPCODE SEQUENCE MATCHER

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Bethlehem, PA 18018

The motivation for writing this program stemmed from the fact that I have two machine code versions of the same 650X assembler (ASM65 by Wayne Wall, dated 1 May 77 and 13 Jun 77 respectively) but I only have a listing of the older version. Both are just short of 4 K bytes long. I wished to make some local changes to the newer version and therefore needed to establish a means of correspondence between it and the listing. A disassembler is helpful here but not adequate because of discontinuities in the two codes which make forward references very difficult to correlate manually.

I felt that when a program has been heavily modified, many opcode sequence segments would remain constant even while their respective operands differ. Therefore, what was needed was a program that would correlate and point to parallel sequences of opcodes.

Several assumptions were made in order to simplify the programming task. It was presumed that the basic order of appearance of major portions of the code would be the same since there seemed to be little advantage in shuffling the deck, as it were. Also, in order to minimize the effect of spurious matches, it was decided that only significant sequences need be reported and that no portion of the code would be reported as a match more than once. This position saves the program, for example, from reporting every possible LDA, STA opcode sequence pairing (or even all of those of the same address mode).

Process Description

As written, the scanning process of the matching program starts at the beginning of the two code strings, A and B, to be examined. Both initial positions are assumed to contain opcodes. An index or pointer to the B string is, in effect, moved along B, from opcode to opcode, until a match with the current A string opcode is found. If no match is found before the B list is exhausted, the A pointer is moved to the next A opcode position while the B pointer is reset to its previous starting point. This general procedure is repeated until the A list is exhausted, at which time the program terminates.

When a match is found, both pointers are moved together along their respective lists, from opcode to opcode, until the opcodes fail to match each other. If the matching sequence is significantly long the size and the start and end of both segments is displayed. The search for additional matching segments is resumed from the end of the just-reported segments so that their opcode elements cannot be matched more than once.

If the completed sequence is not significant, it is not displayed and the search is resumed from where the short sequence began, as if there had been no match at all.

The definition of significance refers to the minimum acceptable number of matching codes in a continuous sequence. The particular values used are left to the user. While our experience has shown a minimum value of eight to be useful, the actual values should reflect the length of the code being examined and the degree to which it has been hacked up.

The effect of a too-low significance value often results in a fewer number of matches being rep-

orted, rather than more as one might expect. This is because a spurious match of short segments can have the effect of masking out longer possible matches which would use the same code items were they still available.

Operation

To operate the opcode matching program both lists of code must be in memory. They may be in ROM. They need not be at their operating address. (Indeed, if they have the same address at least one must be somewhere else anyway). Since the matching program reports storage, rather than operating addresses it is useful to choose storage addresses that have some degree of correspondence to the operating addresses, e.g., code operating at \$21E3 might be stored at \$41E3.

Enter initial values (all in hex LO,HI) as follows:

\$0000,01	Significance value
\$0002,03	Start of list A
\$0004,05	Start of list B
\$0006,07	End of list A
\$0008,09	End of list B

Only the starting address will be modified during program execution. The program will initially assume that the value at the start location is an opcode.

To run the program enter at OPMACH. As written, it will terminate by jumping to the monitor from END01. The routine may be made into a subroutine by placing an RTS here.

Since the program cranks the data a lot, there will be what seem to be long pauses between outputs. The program requires about 2 minutes to compare the aforementioned assemblers.

Results

Several sets of results, using significance values of \$06, \$08 and \$0A are shown below. In order to have both versions of code resident at the same time, it was necessary to store one version, at address \$4000.

About 64 percent of the code of the two versions of the assembler correlate when a significance value of 8 is used. This is a reasonable percentage when one considers the fact that the non-significant, non-reported, sequences are easily identified since they lie in the same relative position between reported sequences.

An extensive manual comparison of the two code sets was made. (So much for the work-saving aspects of the program!) No false matches were identified when a significance value of 8 was used.

Variations for Text Processing

Interesting variants of the program are possible. By altering or replacing the list pointer increment routines, AINC and BINC, the nature of the list pointer incrementation may be changed from the current conditional increment based on opcode to some other condition or to a constant such as plus one.

With a constant increment of one, the matching program may be used to compare sequences of any

textural material in a somewhat crude, one for one fashion.

By having separate increment subroutines when seeking to locate the start of a matching segment in contrast to the incremental routines used when "running-out" a sequence, some fairly powerful text processing capabilities may be obtained at little additional cost. For example, when seeking to locate matching segments in natural language text, we might wish to start with the initial character of alphabetic strings, i.e., words. Therefore, by incrementing past all non-alphabetic characters to the next alphabetic character we can both speed up the process and insure that our sequences start with (what we have operationally defined as) words.

Similar techniques may be employed in the (now

separate) within sequence increment routines to ignore, (i.e., increment past,) any non-alphabetic characters such as control characters, numbers, punctuation or whatever we like. Thus we are able to obtain a far more flexible and hopefully more useful definition of a matching sequence.

Conclusions

The general techniques illustrated here are both effective and useful. The conditional matching approach has not been fully explored, but it is clear that it has interesting possibilities in the area of text processing. In the present application, correlating two lengthy strings of machine code, the approach made practical what otherwise would have been a difficult and dull task.

```

;      **** OPCODE SEQUENCE MATCHER ****
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;
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;
;
;      .LOC $0000
;
;      USER DEFINED VARIABLES (LO,HI)
0000 00 00 SIGNIF: .WORD          ;SIGNIFICANCE
0002 00 00 ABASE: .WORD          ;START OF LIST A
0004 00 00 BBASE: .WORD          ;START OF LIST B
0006 00 00 AMAX: .WORD          ;END OF LIST A
0008 00 00 BMAX: .WORD          ;END OF LIST B
;
;      OTHER PROGRAM VARIABLES
000A 00 00 APOINT: .WORD          ;LIST A POINTER
000C 00 00 BPOINT: .WORD          ;LIST B POINTER
000E 00 00 ASAVE: .WORD          ;LIST A SEQUENCE START
0010 00 00 BSAVE: .WORD          ;LIST B SEQUENCE START
0012 00 00 COUNT: .WORD          ;SEQUENCE COUNTER
;
;      EXTERNAL SUBROUTINES (IN KIM)
;      .DEF START=$1C4F          ;MONITOR RETURN POINT
;      .DEF CRLF=$1E2F          ;CARRIAGE RETURN
;      .DEF OUTCH=$1EA0          ;DISPLA A CHAR
;      .DEF PRTBYT=$1E3B          ;DISPLA HEX BYTE
;      .DEF OUTSP=$1E9E          ;DISPLA A SPACE
;
;      .LOC $0200
;
0200 20 2F 1E OPMACH: JSR      CRLF
0203 A2 29          LDX#      $29          ;SIGN + HEADER COUNT
0205 BD 4F 03 OPMCH1: LDAX     SIGN          ;DISPLAY HEADER
0208 20 A0 1E          JSR      OUTCH
020B CA          DEX
020C 10 F7          BPL      OPMCH1
020E A5 01          LDA      SIGNIF+1
0210 20 3B 1E          JSR      PRTBYT          ;DISPLAY SIGNIF HI
0213 A5 00          LDA      SIGNIF
0215 20 3B 1E          JSR      PRTBYT          ;DISPLAY SIGNIF LO
0218 20 2F 1E          JSR      CRLF
021B 20 3B 03          JSR      BASPNT          ;POINTERS=BASES

```



```

021E A5 03      DO1:   LDA   ABASE+1
0220 C5 07      CMP   AMAX+1
0222 30 09      BMI   IF1           ;BR IF WHOLE JOB NOT DONE
0224 A5 02      LDA   ABASE
0226 C5 06      CMP   AMAX
0228 30 03      BMI   IF1           ;BR IF WHOLE JOB NOT DONE
022A 4C B7 02   JMP   ENDO1        ;HERE IF WHOLE JOB DONE
022D A2 00      IF1:   LDX# 0       ;DOES CURRENT PAIR MATCH*
022F A1 0A      LDAX@ APOINT
0231 C1 0C      CMPX@ BPOINT
0233 D0 64      SNE   ELS1        ;BR IF NOT THE SAME
0235 86 12      THEN1: STX   COUNT  ;HERE ON SAME
0237 86 13      STX   COUNT+1     ;CLEAR THE COUNTER
0239 A2 03      LDX# 3
023B B5 0A      THN1A: LDAX APOINT ;SAVES=POINTERS
023D 95 0E      STAX ASAVE
023F CA        DEX
0240 10 F9      BPL   THN1A
0242 A2 00      DO2:   LDX# 0       ;DO TILL NOT THE SAME
0244 A1 0A      LDAX@ APOINT
0246 C1 0C      CMPX@ BPOINT
0248 D0 26      BNE   ENDO2        ;BR IF NOT THE SAME
024A A5 0B      LDA   APOINT+1
024C C5 07      CMP   AMAX+1
024E 30 06      BMI   EXP21        ;BR IF LESS THAN
0250 A5 0A      LDA   APOINT
0252 C5 06      CMP   AMAX
0254 10 1A      BPL   ENDO2        ;BR TO ENDO
0256 A5 0D      EXP21: LDA   BPOINT+1
0258 C5 09      CMP   BMAX+1
025A 30 06      BMI   EXP22        ;BR IF LESS THAN
025C A5 0C      LDA   BPOINT
025E C5 08      CMP   BMAX
0260 10 0E      BPL   ENDO2        ;BR TO ENDO IF LIMIT REACHED
0262 20 BA 02   EXP22: JSR   AINC    ;MOVE A POINTER TO NEXT A OPCODE
0264 20 CE 02   JSR   BINC    ;MOVE B POINTER TO NEXT B OPCODE
0266 E6 12      INC   COUNT
0268 D0 D6      BNE   DO2
026C E6 13      INC   COUNT+1
026E D0 D2      BNE   DO2          ;BR ALWAYS TO TOP OF DO
0270 EA        ENDO2: NOP        ;A WASTED BYTE FOR "STRUCTURE"
0271 A5 13      IF2:   LDA   COUNT+1
0273 C5 01      CMP   SIGNIF+1
0275 30 0F      BMI   ELS2        ;BR IF NOT SIGNIF
0277 A5 12      LDA   COUNT
0279 C5 00      CMP   SIGNIF
027B 30 09      BMI   ELS2
027D 20 FE 02   THEN2: JSR   REPORT ;HERE ON SIGNIF. OUTPUT RESULT
0280 20 45 03   JSR   PNTBAS    ;POINTERS=BASES
0282 4C 96 02   JMP   ENDIF2
0284 A2 01      ELS2:   LDX# 1
0286 20 3D 03   JSR   BASPT1    ;APOINT=ABASE
0288 A5 10      LDA   BSAVE
028D 85 0C      STA   BPOINT
028F A5 11      LDA   BSAVE+1
0291 85 0D      STA   BPOINT+1
0293 20 CE 02   JSR   BINC
0296 4C 9C 02   ENDIF2: JMP   ENDIF1
0299 20 CE 02   ELS1:   JSR   BINC ;
029C EA        ENDIF1: NOP        ;ANOTHER SOP TO "STRUCTURE"
029D A5 0D      IF3:   LDA   BPOINT+1
029F C5 09      CMP   BMAX+1
02A1 30 11      BMI   ENDIF3      ;BR IF NOT DONE
02A3 A5 0C      LDA   BPOINT
02A5 C5 08      CMP   BMAX
02A7 30 0B      BMI   ENDIF3      ;BR IF NOT DONE
02A9 20 3B 03   THEN3: JSR   BASPNT
02AC 20 BA 02   JSR   AINC
02AF A2 01      LDX# 1
02B1 20 47 03   JSR   PNTBS1
02B4 4C 1E 02   ENDIF3: JMP   DO1
02B7 4C 4F 1C   ENDO1: JMP   START

```

```

;
; SUBROUTINES FOLLOW
;
; MOVE TO NEXT A OPCODE
02BA A2 00 AINC: LDX# 0
02BC A1 0A LDAX@ APOINT ;GET OPCODE
02BE 20 E2 02 JSR BYTCNT ;CALCULATE SIZE
02C1 8A TXA ;RESULT RETURNED IN X
02C2 18 CLC
02C3 65 0A ADC APOINT ;ADD RESULT TO POINTER
02C5 85 0A STA APOINT
02C7 A5 0B LDA APOINT+1
02C9 69 00 ADC# 0
02CB 85 0B STA APOINT+1
02CD 60 RTS

;
; MOVE TO NEXT B OPCODE
02CE A2 00 BINC: LDX# 0
02D0 A1 0C LDAX@ BPOINT ;GET OPCODE
02D2 20 E2 02 JSR BYTCNT ;CALCULATE SIZE
02D5 8A TXA ;RESULT RETURNED IN X
02D6 18 CLC
02D7 65 0C ADC BPOINT ;ADD RESULT TO POINTER
02D9 85 0C STA BPOINT
02DB A5 0D LDA BPOINT+1
02DD 69 00 ADC# 0
02DF 85 0D STA BPOINT+1
02E1 60 RTS

;
; CALCULATE SIZE OF OPERAND (+1)
; BY H. T. GORDON (SEE DDJ #22. P.5)
02E2 A2 01 BYTCNT: LDX# 1
02E4 2C E8 02 BIT BYTCNT+6 ;TEST BIT 3
02E7 D0 08 BNE HAPOP ;ALL X(8-F)
02E9 C9 20 CMP# $20
02EB F0 0E BEQ THREE ;ONLY $20
02ED 29 9F AND# $9F ;BITS 5,6 OUT
02EF D0 0B BNE TWO ;ALL EXCEPT (0,4,6)0
02F1 29 15 HAPOP: AND# $15 ;RETAINS ONLY BITS 0,2,4
02F3 C9 01 CMP# 1
02F5 F0 05 BEQ TWO ;X(9,B)
02F7 29 05 AND# 5 ;BIT 4 OUT
02F9 F0 02 BEQ ONE ;X(8,A) AND (0,A,6)0
02FB E8 THREE: INX ;RESID. X(9-F)
02FC E8 TWO: INX
02FD 60 ONE: RTS

;
; DISPLAY SIGNIFICANT SEQUENCE LIMITS
02FE A2 01 REPORT: LDX# 1
0300 B5 12 REPT1: LDAX COUNT ;OUTPUT EXTENT OF MATCH
0302 20 3B 1E JSR PRTBYT
0305 CA DEX
0306 10 F8 BPL REPT1

; OUTPUT MULTIPLE SPACES
0308 20 31 03 JSR OUTSP4 ;FOUR SPACES
030B A2 00 LDX# 0
030D B5 0F REPT2: LDAX ASAVE+1 ;OUTPUT START AND
030F 20 3B 1E JSR PRTBYT ; END ADDR OF
0312 B5 0E LDAX ASAVE ; BOTH SEGMENTS
0314 20 3B 1E JSR PRTBYT
0317 20 34 03 JSR OUTSP2
031A B5 0B LDAX APOINT+1
031C 20 3B 1E JSR PRTBYT
031F B5 0A LDAX APOINT
0321 20 3B 1E JSR PRTBYT
0324 20 31 03 JSR OUTSP4
0327 E8 INX
0328 E8 INX
0329 E0 03 CPX# 3
032B 30 E0 BMI REPT2
032D 20 2F 1E JSR CRLF
0330 60 RTS

```

```

;
0331 20 34 03 OUTSP4: JSR OUTSP2 ; 4 SPACES
0334 20 9E 1E OUTSP2 JSR OUTSP ; 2 SPACES
0337 20 9E 1E JSR OUTSP
033A 60 RTS

;
; MOVE ABASE & BBASE TO APOINT & BPOINT
033B A2 03 BASPNT: LDX# 3
033D B5 02 BASPT1 LDAX ABASE
033F 95 0A STAX APOINT
0341 CA DEX
0342 10 F9 BPL BASPT1
0344 60 RTS

;
; MOVE APOINT & BPOINT TO ABASE & BBASE
0345 A2 03 PNTBAS: LDX# 3
0347 B5 0A PNTBS1: LDAX APOINT
0349 95 02 STAX ABASE
034B CA DEX
034C 10 F9 BPL PNTBS1
034E 60 RTS

;
SIGN: .ASCII ' = FINGIS '

034F 20
0350 3D
0351 20
0352 46
0353 49
0354 4E
0355 47
0356 49
0357 53
0358 20
0359 20

HEADER: .ASCII 'OT MORF OT MORF EZIS

035A 4F
035B 54
035C 20
035D 20
035E 20
035F 4D
0360 4F
0361 52
0362 46
0363 20
0364 20
0365 20
0366 20
0367 20
0368 4F
0369 54
036A 20
036B 20
036C 20
036D 4D
036E 4F
036F 52
0370 46
0371 20
0372 20
0373 20
0374 20
0375 45
0376 5A
0377 49
0378 53

;
.END

0379
0000 SIGNIF 02BA AINC
0002 ABASE 02CE BINC
0004 BBASE 0271 IF2
0006 AMAX 0286 ELS2
0008 BMAX 02BA AINC
000A APOINT 02CE BINC
000C BPOINT 0271 IF2
000E ASAVE 0286 ELS2
0010 BSAVE 027D THEN2
0012 COUNT 02FE REPORT
1C4F START 0345 PNTBAS
1E2F CRLF 0296 ENDIF2
1EA0 OUTCH 033D BASPT1
1E3B PRTBYT 029C ENDIF1
1E9E OUTSP 029D IF3
0200 OPMACH 02B4 ENDIF3
0205 OPMCH1 02A9 THEN3
034F SIGN 0347 PNTBS1
033B BASPNT 02E2 BYTCNT
021E DO1 02F1 HAFOP
022D IF1 02FB THREE
02B7 END01 02FC TWO
0299 ELS1 02FD ONE
0235 THEN1 0300 REPT1
023B THN1A 0331 OUTSP4
0242 DO2 030D REPT2
0270 END02 0334 OUTSP2
0256 EXP21 035A HEADER
0262 EXP22

```

	SIZE	FROM	TO	FROM	TO	SIGNIF = 0006
	0026	2000	2052	4000	4052	
x	0007	2069	207B	4093	40A5	
x	0006	2099	20A5	42C2	42CE	
x	0006	2224	2234	437C	438C	
x	000A	2237	224D	4784	479A	
x	000B	274E	2761	479D	47B0	
x	0008	279D	27AC	47BB	47CA	
	007A	28D1	29BE	47CF	48BC	
	0008	29BF	29D1	48BC	48CE	
	0019	29DB	2A0D	48CE	4900	
	004D	2A17	2AC6	492D	49DC	
	002E	2ACB	2B33	49E1	4A49	
	0035	2B6E	2BE5	4A49	4AC0	
	000C	2BF2	2C04	4ACD	4ADF	
	0106	2CE2	2F01	4B27	4D46	

Note:
items tagged with
an 'x' represent
false matches.

	SIZE	FROM	TO	FROM	TO	SIGNIF = 0008
	0026	2000	2052	4000	4052	
	003D	206C	20F0	4052	40D6	
	0020	20F3	213C	40D6	411F	
	001F	213C	2180	4122	4166	
	000E	2187	21A7	416D	418D	
	0046	21AA	224D	4198	423B	
	0087	2275	2394	4258	4377	
	0009	23A8	23BB	438F	43A2	
	0126	23C0	25E6	43A2	45C8	
	004C	25F1	269F	45C8	4676	
	0087	26C1	27C1	4692	4792	
	000E	27C8	27E2	479D	47B7	
	000C	27E5	27F9	47BB	47CF	
	007A	28D1	29BE	47CF	48BC	
	0008	29BF	29D1	48BC	48CE	
	0019	29DB	2A0D	48CE	4900	
	004D	2A17	2AC6	492D	49DC	
	002E	2ACB	2B33	49E1	4A49	
	0035	2B6E	2BE5	4A49	4AC0	
	000C	2BF2	2C04	4ACD	4ADF	
	0087	2DE5	2F01	4C2A	4D46	

	SIZE	FROM	TO	FROM	TO	SIGNIF = 000A
	0026	2000	2052	4000	4052	
	003D	206C	20F0	4052	40D6	
	0020	20F3	213C	40D6	411F	
	001F	213C	2180	4122	4166	
	000E	2187	21A7	416D	418D	
	0046	21AA	224D	4198	423B	
	0089	2271	2394	4254	4377	
	0126	23C0	25E6	43A2	45C8	
	004C	25F1	269F	45C8	4676	
	0089	26BC	27C1	468D	4792	
	000E	27C8	27E2	479D	47B7	
	000C	27E5	27F9	47BB	47CF	
	007A	28D1	29BE	47CF	48BC	
	001D	29D1	2A0D	48C4	4900	
	004D	2A17	2AC6	492D	49DC	
	002E	2ACB	2B33	49E1	4A49	
	0035	2B6E	2BE5	4A49	4AC0	
	000C	2BF2	2C04	4ACD	4ADF	
	0089	2DE1	2F01	4C26	4D46	

A MEMORY TEST PROGRAM FOR THE COMMODORE PET

Michael J. McCann
28 Ravenswood Terrace
Cheektowaga, NY 14225

It would be useful and convenient to be able to test PET's memory with a testing program rather than sending the machine back to Commodore for service. Towards this end I have written a memory test program in Commodore BASIC for the PET. The program is well commented, and should be self documenting. (see listing)

Since the program occupies the lowest 4K of PET's memory, use of the program will require that the lowest 4K of memory be operating normally. The amount of time required to run this program rapidly increases as the number of bytes under test is increased (see Figure 1.)

Testing large blocks of memory results in more rigorous testing at the expense of time. Therefore, when using this program the user will have to make a decision regarding rigor vs. time. As a bare minimum, I would suggest testing 100 bytes at a time.

In closing I would suggest that you get this program up and running before you have a problem. It may prove difficult to get a new program working when you have a major system problem.

```
10 REM MEMORY TEST PROGRAM FOR THE COMMODORE PET
20 REM PROGRAM WILL RUN ON 8K PET
30 REM BY MICHAEL J MCCANN
40 PRINT CHR$(147):EE=0:I=0
50 INPUT "START ADDRESS"; SA
60 IF SA<4097 OR SA>65535 GOTO 50
70 INPUT "STOP ADDRESS"; SP
80 IF ST>65535 OR SP<SA GOTO 70
90 PRINT CHR$(147):PRINT:PRINT
100 PRINT TAB(5)"WORKING"
105 PRINT:PRINT"FAULT IN ADDRESS:";
110 REM MEMORY ACCESS AND LOGIC CIRCUITRY TEST
120 REM WRITE ALL 0
130 FOR A=SA TO SP
140 POKE A,0
150 NEXT
160 REM CHECK FOR CORRECTNESS (=0)
170 FOR A=SA TO SP
180 IF PEEK(A)<>0 THEN EE=1:GOSUB 800
190 NEXT
200 REM WRITE ALL 255
210 FOR A=SA TO SP
220 POKE A,255
230 NEXT
240 REM CHECK FOR CORRECTNESS(=255)
250 FOR A=SA TO SP
260 IF PEEK(A)<>255 THEN EE=1:GOSUB 800
270 NEXT
280 REM BEAT TESTS
290 REM WRITE ALL 0
300 FOR A=SA TO SP
310 POKE A,0
320 NEXT
330 REM BEAT ONE ADDRESS WITH 255
335 AD=SA+I
340 POKE AD,255
350 POKE AD,255
360 POKE AD,255
370 POKE AD,255
380 POKE AD,255
```

```
390 REM CHECK ALL FOR 0 EXCEPT THE ADDRESS
    BEAT WITH 255
400 FOR A=SA TO SP
410 IF A=AD GOTO 430
420 IF PEEK(A)<>0 THEN EE=1:GOSUB 800
430 NEXT
440 IF AD=SP+1 THEN POKE AD,0: I=I+1: GOTO 335
450 I=0
460 REM WRITE ALL 255
470 FOR A=SA TO SP
480 POKE A,255
490 NEXT
500 REM BEAT ONE ADDRESS WITH 0
505 AD=SA+I
510 POKE AD,0
520 POKE AD,0
530 POKE AD,0
540 POKE AD,0
550 POKE AD,0
560 REM CHECK ALL FOR 255 EXCEPT THE ADDRESS
    BEAT WITH 0
570 FOR A=SA TO SP
580 IF A=AD GOTO 600
590 IF PEEK(A)<>255 THEN EE=1:GOSUB 800
600 NEXT
610 IF AD<>SP+1 THEN I=I+1:POKE AD,255:GOTO 505
620 REM ADDRESSING TEST
630 REM WRITE CONSECUTIVE INTEGERS (0-255) IN
    ALL LOCATIONS UNDER TEST
640 I=0
650 FOR A=SA TO SP
660 IF I=256 THEN I=0
670 POKE A,I
680 I=I+1
690 NEXT
700 REM CHECK FOR CORRECTNESS
705 I=0
710 FOR A=SA TO SP
720 IF I=256 THEN I=0
730 IF PEEK(A)<>I THEN EE=1:GOSUB 800
740 I=I+1
750 NEXT
760 PRINT
770 IF EE=0 THEN PRINT" NO MEMORY PROBLEMS DE-
    TECTED"
780 END
800 PRINT A;
810 RETURN
```

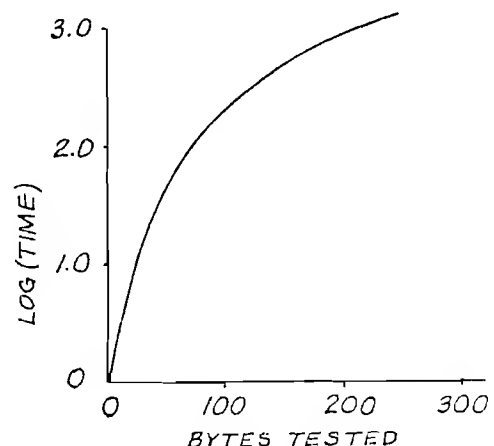


Figure 1. Graph of Log(Time Required) vs. Number of Bytes Tested. (Time in Seconds)

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MICROBES, A SUGGESTION, AND AN APOLOGY

MICROBES

Ah, how often it is the things in life which appear so simple that cause us great anguish and gnashing of teeth. We present here what we hope is the last microbe in "A KIM Beeper" 4:43:

The beeper (MICRO 5:24) still doesn't beep - it only clicks! This results from the EOR, of address 010D, operating on two identical operands except for the first iteration in each "beep."

This results in a zero being stored in PBD, i.e., no toggling.

The low-order bit of A should be set before each EOR. But, more simply, EOR PBD, STA PBD may be replaced by INC PBD (and 3 NOP's, to preserve the branch)

The latter change is tested and beeping in the background.

*Regards,
Randy Graves*

Even "Apple Pi" isn't simple any more! Neil D. Lipson of the Philadelphia Apple Users Group writes that "The Pi article by Bob Bishop (MICRO 6:15) is missing one thing. Add HIMEM:4096." But, that's not all! John Paladini writes that: "The value of Pi was not computed to 1000 decimal places, but rather 998. Such inaccuracies occur when computing a series where billions of calculations are required. My best guess is that in order to calculate Pi to 1,000 places using the given series one would have to compute to 1,004 places. The last two digits should read 89 not 96."

Although we made special efforts to make the McCann article "A Simple 6502 Assembler for the PET" error free, including careful proofing by us and the author, a couple of microbes slipped through. C. E. White and David Hustvedt wrote about the following problems:

1. After entering the program from the keyboard your must save it on tape before going through "RUN" again. If you don't EN and ZZ are set to zero.

2. Errors in the typed listing are:

1040 HX\$+5X\$...	S/B	HX\$=5X\$
4030 ;MN\$(1B);...	S/B	;MN\$(1B);
5020 ;TAB(27) OP	S/B	;TAB(27);OP
6060 ...NULL,0,NULL,0	S/B	three NULL,0's
6100 DATA CLC,1,...	S/B	DATA CLI,1,
6120 ..JMI,3,...	S/B	...JMPI,3,
6250 ...CPX,2,...	S/B	...CPXZ,2,
14350 GOTO 14380	S/B	GOTO 14480

3. When using the "BRK" command the system outputs the error statement "ILLEGAL QUANTITY ERROR IN 10020", READY.

A SUGGESTION

We finally heard from an OSI owner. John Sheffield writes that the BASIC Disassembler for Apple and PET by McCann (MICRO 5:25) can work on an OSI Challenger IIP with only a small change: "In each line where BY% appears (lines 10, 30, 3050) just change it to BY and everything works fine. Change to read like this:

```
10 DIM MN$(256),BY(256),CO$(16)
30 READ MN$(E),BY(E)
delete line 100
3050 ON BY(1B) GOTO 3060,3090,4050
```

That's all that is needed. By the way that program works on IIP's with 8K of RAM or more." I would be lead to believe that the BASIC Assembler would work with similar modifications.

John Sheffield had a "p.s." on his letter which said "don't let the IIP be buried under all the Apples and PETs". The staff of MICRO would love to publish material about the OSI products, if only we had some to print! In our first year we received only two articles about OSI. The first was one we "leaned on" a friend for when MICRO was just starting and needed material. The second was a scathing blast at OSI from top to bottom by an obviously disgruntled customer! We do not publish strongly negative material on the basis of a single input, and therefore this article was not published. If there are OSI owners with something to share, MICRO will be most happy to hear from you and print your info.

AN APOLOGY

One of the trade marks of MICRO has been quality. We have made a great effort to obtain good articles and to present them in a high quality publication. We must therefore apologize for the printing quality of MICRO number 6. By the time we got the material back from the printer, who had done a reasonably good job on issues number 4 and 5, it was too late to do anything about the inferior quality of the product except to throw out obviously bad copies. We have gotten some letters and calls from readers who received incomplete or unreadable copies. If you have such a problem, please notify us by mail indicating which pages were defective, and we will promptly replace them.

We apologize for the poor quality of issue 6. We have changed printers starting with this issue, and hope that the quality will be better.

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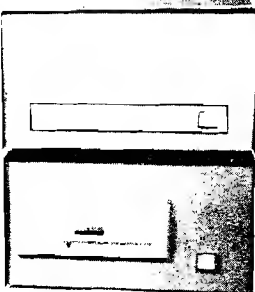
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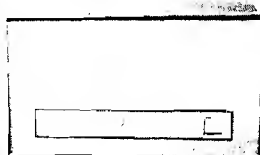
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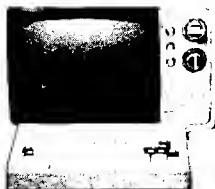
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System: PET
Memory: 8K
Language: BASIC and Assembly Language
Hardware: Standard PET
Description: CURSOR is a cassette magazine with proven programs written just for the 8K PET. Each month the subscriber receives a C-30 cassette with five or more high quality programs for the PET. People can't read this "magnetic magazine", but the PET can! The CURSOR staff includes professional programmers who design and write many of the programs. They also carefully edit programs which are purchased from individual authors.
Copies: Not specified
Price: \$24 for 12 monthly issues
Includes: Cassette
Authors: Many and varied
Available from:
Ron Jeffries, Publisher
CURSOR
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Name: PET Schematics and PET ROM Routines
System: PET
Memory: None
Language: None
Hardware: None
Description: PET Schematics is a very complete set of accurately and painstakingly drawn schematics about your PET. It includes a 24" x 30" CPU board, plus oversized drawings of the Video Monitor and Tape Recorder, plus complete Parts layout - all the things you hoped to get from Commodore, but didn't!
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Available from:
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Name: S-C Assembler II
System: Apple II
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Language: Assembly language
Hardware: Apple II, optional printer
Description: Combined text editor and assembler carefully integrated with the Apple II ROM-based routines. Editor includes full Apple II screen editing, BASIC-like line-number editing, tab stops, and renumbering. LOAD, SAVE, and APPEND commands for cassette storage. Standard Apple II syntax for opcodes and address modes. Labels (1 to 4 characters), arithmetic expressions, and comments. English language error messages. Monitor commands directly available within assembler. Speed and suspension control over listing and assembly.
Copies: Just released, over 100 sold.
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Includes: Cassette in Apple II format and a 28 page reference manual.
Author: Bob Sander-Cederlof
Available from:
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Name: PL/65 or CSL/65
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Language: Machine language.
Hardware: Rockwell SYSTEM 65
Description: A high-level language resembling PL/1 and ALGOL is now available to designers developing programs for the 6500 microprocessor family using either the SYSTEM 65 development system of the PDP 11 computer. PL/65 is considerably easier to use than assembly language or object code. The PL/65 compiler outputs source code to the SYSTEM 65's resident assembler. This permits enhancing or debugging at the assembler level before object code is generated. In addition, PL/65 statements may be mixed with assembly language instructions for timing or code optimization.
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\$500 from COMPAS.

Includes: Minifloppy diskette.
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Available from:
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COMPAS - Computer Applications Corp.
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 Hardware: Not specified.
 Description: A reverse polish scientific calculator program, ideally suited for scientific and educational applications. Supports single key execution of more than 50 forward and inverse arithmetic, algebraic, trigonometric and exponential functions. It implements calculations in binary, octal, decimal, and hexadecimal modes with single keystroke conversion between modes and simultaneous decimal equivalent display. It also allows the recording and playback of calculator programs on cassette tape permitting the use of most calculator software already in existence up to a limit of 255 steps.
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 Language: Applesoft II
 Hardware: Apple II
 Description: Sophisticated financial programs used to aid in investment analysis. The following programs are currently available: Black-Scholes Option Analysis, Security Analysis using the Capital Asset Pricing Model, Bond Pricing I and II, Cash Flow and Present Value Analysis I and II, Stock Valuation, Rates of Return, Calculations and Mortgage Analysis.
 Copies: Just released.
 Price: \$15.00 each or \$50.00 for all 9 programs
 Includes: Cassette, annotated source listings, operating and modifying instructions, sample runs and background information.
 Author: Eric Rosenfeld
 Available from:
 Eric Rosenfeld
 70 Lancaster Road
 Arlington, MA 02174

Name: MICROCHESS
 Systems: PET and Apple II
 Memory: PET - 8K/Apple II 16K
 Language: 6502 Machine Language
 Hardware: Standard PET or Apple II
 Description: MICROCHESS is the culmination of two years of chessplaying program development by Peter Jennings, author of the famous 1K byte chess program for the KIM-1. MICROCHESS offers eight levels of play to suit everyone from the beginner learning chess to the serious player. It examines positions as many as 6 moves ahead, and includes a chess clock for tournament play. Every move is checked for legality and the current position is displayed on a graphic chessboard. You can play White or Black, set up and play from special board positions, or even watch the computer play against itself.
 Copies: Not specified.
 Price: \$19.95
 Includes: Not specified.
 Author: Peter Jennings
 Available from:
 Personal Software
 P.O. Box 136
 Cambridge, MA 02138
 617/783-0694

Name: Apple II BASEBALL
 System: Apple II
 Memory: 16K or more
 Language: Integer BASIC
 Hardware: Standard Apple II
 Description: An interactive baseball game that uses color graphics extensively. You can play a 7 or 9 inning game with a friend, (it will handle extra innings), or play alone against the computer. Has sound effects with men running bases. Keeps track of team runs, hits, innings, balls and strikes, outs, batter-up and uses paddle input to interact with the game. Uses every available byte of memory.
 Copies: Just released.
 (Dealers inquiries invited)
 Price: \$12.50
 Includes: Game Cassette, User Booklet with complete BASIC listing.
 Authors: Pat Chirichella and Annette Nappi
 Available from:
 Pat Chirichella
 506 Fairview Avenue
 Ridgewood, NY 11237

Name: DDT-65 Dynamic Debugging Tool
 System: Any 6502 based system
 Memory: 3K RAM/1K RAM for loader
 Language: Machine Language
 Hardware: 32 char/line terminal
 Description: DDT-65 is an advanced debugger that allows easy assembly and disassembly in 650X mnemonics. Software single-stepping and automatic breakpoint insertion/deletion allow debugging of code even in PROM. DDT-65 comes in a relocatable form on tape for loading into any memory or for PROM programming.
 Copies: 11+
 Price: \$25.00
 Include: 10 page manual, relocating tape cassette.
 Ordering Info: KIM format cassette - K
 Kansas City at 300 baud for OSI - O
 Kansas City at 300 baud for TIM/JOLT - T
 Author: Rich Challen
 Available from:
 Rich Challen
 939 Indian Ridge Drive
 Lynchburg, VA 24502

APPLE CALLS AND HEX-DECIMAL CONVERSION

Marc Schwartz
220 Everit Street
New Haven, CT 06511

Rich Auricchio's "Programmer's Guide to the Apple II" (MICRO #4, April/May 1978) is a very useful step in getting out printed materials to help users fully exploit the Apple's potential. That his table of monitor routines can be used in BASIC programming is worth noting.

Many monitor routines can be accessed in BASIC by CALL commands addressed to the location of the first step of the routine. If the routine is located in hex locations 0000 to 4000, it is necessary only to convert the hex location to decimal and write CALL before the decimal number. Thus a routine located at hex 1E would be accessed by the command: CALL 30, since hex 001E = decimal 30.

If you do not have a hex-decimal conversion table handy, you can convert larger numbers to decimal with the help of the Apple by the following steps:

1. Start in BASIC (necessary for step 2)
2. Multiply the first (of four) hex digits by 4096, the second by 256, the third by 16 and the fourth by one. Add the four numbers to get the decimal equivalent. For example, to get the decimal conversion of 03E7, with the Apple in BASIC, press Control/C and type

```
>PRINT 0*4096 + 3*256 + 14*16 + 7
```

then press RETURN. You'll get your decimal answer: 839. To begin a monitor routine you wrote starting at 03E7, merely put CALL 839 in your program.

If the hex location of the routine is between C000 and FFFF, then another method of figuring out the corresponding decimal location must be used.

1. Start in BASIC
2. Press the RESET button.
3. Take the hex location of the routine and subtract it from FFFF. The Apple will help you do this; subtract each pair of hex digits from FF and press RETURN. The Apple will print the answer to each subtraction for you. For example the hex location of the routine to home cursor and clear screen is \$FC58.

```
* FF - FC RETURN  
= 03  
* FF - 58 RETURN  
= A7
```

So, \$FFFF - \$FC58 = \$03A7.

Now convert to decimal as above, using BASIC (control/C) to assist you.

```
>PRINT 0*4096 + 3*256 + 10*16 + 7
```

and after pressing RETURN you will have your answer, 935.

4. Add one to the total, here giving 936.
5. Make the new total negative, or -936.
6. That's it. Now just put a CALL in front of the number: CALL -936.

Of course, these steps of converting hex locations to decimal are the same ones to take if you want to access the PEEK or POKE functions of the Apple. In all, they allow the BASIC programmer to take much fuller advantage of the capabilities of the computer.

And while on the subject of hex-decimal conversion, the Apple can help in decimal to hex conversion as well. For example to find the hex of a number, say 8765:

1. Start in BASIC
2. Divide the number by 4096, then find the remainder:

```
>PRINT 8765/4096,8765MOD4096 (return)  
2      573
```

3. Repeat the process with 256 and 16:

```
>PRINT 573/256,573MOD256 (return)  
2      61  
>PRINT 61/16, 61 MOD 16 (return)  
3      13
```

...giving 2 2 3 13 or 223C.

WRITING FOR MICRO

One of the reasons we like the 6502 is that it seems to attract a lot of very interesting, active, enthusiastic users. We spend several hours each week talking to people who are so excited about what they are doing with their system that they just have to talk to someone. Oh, sometimes they pretend they have some "burning" question or want to order some small item, but really they mostly want to tell someone about all of the fun they are having or the discoveries they are making.

While we enjoy these conversations, and consider them one of the "Fringe benefits" of editing MICRO, it disturbs us that many of these enthusiasts who are willing to spend five to ten dollars on a phone call to us, are not willing to spend a little time writing down their informa-

tion for publication in MICRO where thousands can share it (and they can earn a few dollars).

MICRO, in order to serve its main purpose of presenting information about all aspects of the 6502 world, needs to receive information from a wide variety of sources. To achieve a more balanced content, we desperately need articles on: industrial, educational, business, home, and other real applications of systems; non-KIM, -APPLE, -PET systems, homebrew and commercial; techniques for programming, interfacing, and expanding systems; and many other topics. Look to your own experience. If you have anything to share, then take the time to write it down. The "Manuscript Cover Sheet" on the next page should serve as a guide and make it a little easier to submit your article.

MANUSCRIPT COVER SHEET

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Proposed Title: _____

Author(s) Name(s): _____

Mailing Address: _____
(This will be published.)

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A Few Suggestions

All text material will be retyped. Therefore your format does not matter as long as it is readable. Double spaced, typed, is preferable, but not required. Any figures should be neatly drawn to scale as they will appear in MICRO. If we have to redraw the figures and diagrams, then we normally will pay less for that page. Photographs should be glossy prints either the same size as the final will be or twice the final size. We will re-assemble all programs to obtain clean listings using the syntax we have adopted (see inside back cover - MICRO #1). Since others will be copying your code, please try to thoroughly test it and make sure it is as error free as possible. Submit your articles early. We will try to get a proof back to you for final correction, but with our tight schedule this may not always be possible. Send your manuscripts to:

Robert M. Tripp, Editor, MICRO, P.O. Box 3, So. Chelmsford, MA 01824, U.S.A.

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438 Roslyn Ave.
Akron, OH 44320

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6502 INFORMATION RESOURCES

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438 Roslyn Ave.
Akron, OH 44320

Did you ever wonder just what magazines were the richest sources of information on the 6502 microprocessor, 6502-based microcomputers, accessory hardware and software? For several years this writer has been assembling a bibliography 6502 references related to hobby computers and small business systems (see MICRO No's 1, 3, 4, 5, and 6). A review of the number of times various magazines are cited in the bibliography gives a rough measure of the coverage of these magazines of 6502 related subjects. Even after such a frequency chart is compiled, an accurate comparison is difficult. Some of the magazines have been published longer than others. Some periodicals have been discontinued, others have been merged with continuing publications. Some give a lot of information in the form of ads, others are devoted mostly to authored articles. Regardless of the basis of the tabulation of references, however, some publications are clearly more useful sources of information on the 6502 than others.

The accompanying list of magazines has been compiled from the bibliography. At the top of the list are several publications which specialize in 6502-related subjects. These include this publication, MICRO, as well as the KIM-1/6502 USER NOTES. Also in this category is OHIO SCIENTIFIC'S SMALL SYSTEMS JOURNAL, a publication which covers hardware and software for the Ohio Scientific 6502-based computers. KILOBAUD, BYTE and DR. DOBB'S JOURNAL all give good coverage on the 6502 as well as other microprocessors. KILOBAUD has more hardware and constructional articles than most computer magazines. ON-LINE is devoted mainly to new product announcements and has very frequent references to 6502 related items. Following these come a group of magazines with somewhat less frequent references to the 6502. Finally toward the end of the list are those magazines with only occasional or trivial references to the 6502. An attempt has been made to give up-to-date addresses and subscription rates for the magazines cited.

MICRO
\$6.00 per 6 issues
MICRO
P.O. Box 3
S. Chelmsford, MA 01824

KIM-1/6502 USER NOTES
\$5.00 per 6 issues
Eric Rehnke
P.O. Box 33077
Royalton, OH 44133

OHIO SCIENTIFIC--SMALL SYSTEMS JOURNAL
\$6.00 per year (6 issues)
Ohio Scientific
1333 S. Chillicothe Rd.
Aurora, OH 44202

KILOBAUD
\$15.00 per year
Kilobaud Magazine
Peterborough, NH 03458

BYTE
\$12.00 per year
Byte Publications, Inc.
70 Main St.
Peterborough, NH 03458

DR. DOBB'S JOURNAL
\$12.00 per year (10 issues)
People's Computer Co.
Box E
1263 El Camino Real
Menlo Park, CA 94025

ON-LINE
\$3.75 per year (18 issues)
D. H. Beetle
24695 Santa Cruz Hwy
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PEOPLE'S COMPUTERS (Formerly PCC)
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INTERFACE AGE
\$14.00 per year
McPheters, Wolfe & Jones
16704 Marquardt Ave.
Cerritos, CA 90701

POPULAR ELECTRONICS
\$12.00 per year
Popular Electronics
One Park Ave.
New York, NY 10016

PERSONAL COMPUTING (Formerly MICROTREK)
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1050 Commonwealth Ave.
Boston, MA 02215

73 MAGAZINE
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CREATIVE COMPUTING
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Creative Computing
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SSSC INTERFACE
(Write for information)
Southern California Computer Soc.
1702 Ashland
Santa Monica, CA 90405

EDN (Electronic Design News)
\$25.00 per year
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270 St Paul St.
Denver, CO 80206

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QST
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345 E. 47th St.
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MINI-MICRO SYSTEMS
\$18.00 per year
Modern Data Service
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Hudson, MA 01749

DIGITAL DESIGN
\$20.00 per year
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Boston, MA 02215

ELECTRONIC DESIGN
(26 issues per year)
(Write for subscription info)
Hayden Publishing Co., Inc
50 Essex St.
Rochelle Park, NJ 07662

HAM RADIO
\$12.00 per year
Communications Technology
Greenville, NH 03048

COMPUTER WORLD
\$12.00 per year (trade weekly)
(Write for subscription info)
Computer World
797 Washington St.
Newton, MA 02160

Editor's Note: In addition to the magazines regularly covered by the 6502 Bibliography, the following magazines may also be of interest to various 6502 readers:

PET GAZETTE
Free bi-monthly (Contributions Accepted)
Microcomputer Resource Center
1929 Northport Drive, Room 6
Madison, WI 53704

Robert Purser's REFERENCE LIST
OF COMPUTER CASSETTES
Nov 1978 \$2.00/Feb 1979 \$4.00
Robert Purser
P.O. Box 466
El Dorado, CA 95623

THE SOFTWARE EXCHANGE
\$5.00 per year (6 issues)
The Software Exchange
P.O. Box 55056
Valencia, CA 91355

THE PAPER
\$15.00 per year (10 issues)
The PAPER
P.O. Box 43
Audubon, PA 19407

PET USER NOTES
\$5.00 per year (6 or more issues)
PET User Group
P.O. Box 371
Montgomeryville, PA 18936

CALL A.P.P.L.E.
\$10.00 per year (includes dues)
Apple Puget Sound Program Library Exchar
6708 39th Ave. SW
Seattle, WA 98136

KIM-1 AS A DIGITAL VOLTMETER

Joseph L. Powlette and Charles T. Wright
Hall of Science, Moravian College
Bethlehem, PA 18018

Several programs have been described in the literature which turn a KIM-1 microcomputer into a direct reading frequency counter. In "A Simple Frequency Counter Using the KIM-1" by Charles Husbands (MICRO, No. 3, Pp. 29-32, Feb/Mar, 1978) and in "Here's a Way to Turn KIM Into a Frequency Counter" by Joe Laughter (KIM User's Note Issue 3, Jan, 1977), good use is made of KIM-1's interval timers and decimal mode to produce a useful laboratory instrument. A simple change in hardware will allow these same programs to serve as the basis of a direct reading digital voltmeter. This article describes an inexpensive voltage-to-frequency converter (VFC) circuit which is compatible with these programs and also describes some software modifications which will allow Husbands' program to operate down to low frequency (10 HZ) values.

Hardware Configuration

The VFC circuit is shown in Figure 1. The 4151 chip is manufactured by Raytheon and is available from Active Electronic Sales Corp., P.O. Box 1035, Framingham, MA 01701 for \$5.00 or from Jameco Electronics, 1021 Howard Street, San Carlos, CA 94070 for \$5.95. The circuit parameters given in Figure 1 have been modified from the values suggested by the manufacturer in order to match the pulse requirement for the KIM IRQ signal. The frequency of the output pulse is proportional to the input voltage and the 1K Ω (multiturn) trimpot is used to adjust the full-scale conversion so that 10 volts corresponds to a frequency of 10 KHz. It is not necessary to calibrate the KIM-1 as a frequency meter since any variation in its timing can be compensated for by the trimpot. A known potential is connected to the VFC input and the trimpot adjusted until the KIM readout agrees with the known voltage value. The linearity of the VFC is better than 1% down to 10 mv (linearity of 0.05% can be achieved in a "precision mode" which is described in the Raytheon literature). The circuit will not respond to negative voltages and protection of the chip is provided by the 1N914 diode. If negative voltage readings are also required, the input to the VFC can be pre-

ceded by an absolute value circuit (see IC OP-AMP cookbook by Jung, p. 193, Sams Pub.).

To operate the system using Laughter's software the following connections should be made: 1) the output (pin 3) of the VFC to the PBO input of KIM (pin 9 on the application connector) and 2) PB7 on the KIM to IRQ on the KIM (A-15 to E-4). Execution of the program should cause the voltage to flash on the KIM display in one second intervals.

The software described in Husbands' article will not operate below 500 Hz. This limit is caused by the fact that the contents of the interval timer are read to determine if the 100 millisecond interval has elapsed and since the interval counter continues to count (at a 1T rate) after the interval has timed out, there are times when the contents of the interval timer are again positive. If the interrupt should sample during this time, the branch on minus instruction will not recognize that the interval has elapsed. This problem will manifest itself as a fluctuating value in the display and is most likely to occur at low frequencies. One solution is to establish the interval timer in the interrupt mode and then allow the program to arbitrate the interrupt, i.e., to determine whether the interrupt was due to the input pulse or the expiration of the 100 millisecond interval timer. The necessary changes to Husbands' program are given in Figure 2. The hardware connections are: 1) output of the VFC (pin 3) to the KIM IRQ (pin 4 on the KIM expansion connector), and 2) PB7 on the KIM to IRQ on the KIM (A-15 to E-4). The modified program starts at 0004 with a clear interrupt instruction. Locations 17FE and 17FF should contain 21 00 and 17FA and 17FB should have values 00 10 (or 00 1C).

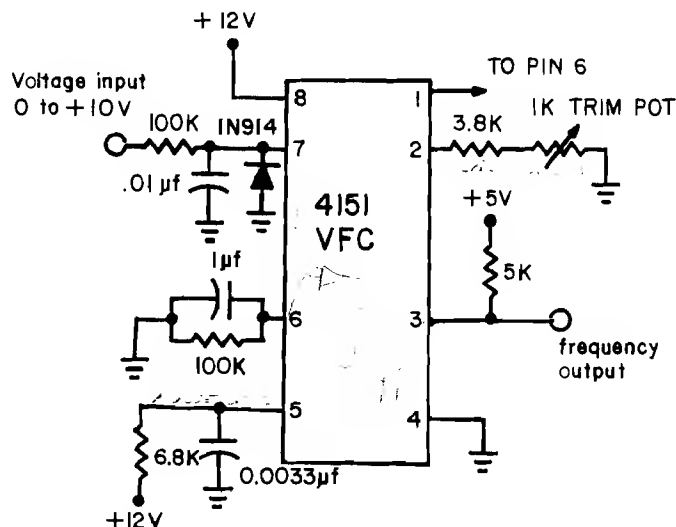


Figure 1. Voltage-to-Frequency Converter (VFC) circuit.

Additional Comments

The program modifications above will also extend Husbands' frequency counter circuit down to 10 Hz (corresponding to 1 input interrupt in 100 milliseconds). Since the 74121 monostable multivibrator does not have an open collector output, PB7 should not be connected (along with the 74121 output) directly to the KIM IRQ. Two solutions are:

1. Leave PB7 unconnected. The expiration of the 100 millisecond clock will be recognized on the next input interrupt after the timer has timed out. The interval timer will not interrupt the microprocessor, however.
2. Connect PB7 to one input of a two input AND gate and the output of the monostable to the second input. The output of the AND gate should be connected to the KIM IRQ. The expiration of the 100 millisecond interval will now also interrupt the processor and will result in a faster response to a change in frequency values (from high to very low) as well as a more accurate low frequency count.

The authors would like to thank Charles Husbands for taking the time to answer our questions and for pointing out the article by Laughter.

ORG \$ 0004

```

0004 58      CLI      clear interrupt flag
.
0014 8D 0F 17 STA      clock in interrupt mode
.
0024 AD 07 17 LDA      read interrupt flag bit 7
.
003C 8D 0F 17 STA      clock in interrupt mode
.

```

Figure 2. Changes in Husbands' program to extend the low frequency range to 10 Hz.

HELPING MICRO HELP YOU

MICRO is published for a number of reasons. One very important reason is to provide a means for the distribution of information about 6502 related products. Our advertising rates are very low in relation to our circulation and specialized audience, and we welcome your money, but that is not what we want to discuss here. MICRO offers several ways for you to get good publicity - FREE ! It will take a little work on your part, but the price is right. There are three regular ways to get coverage in MICRO: the software catalog, the hardware catalog, and the list of 6502 related companies.

THE MICRO SOFTWARE CATALOG

Appearing regularly since issue number 4, the software catalog provides a brief, standardized, description of currently available 6502 software. We were a bit surprised to find that the software catalog was one of the most often mentioned articles in the recent MICRO Reader Feedback. To participate in this catalog, you must follow a few simple rules:

1. The program must be currently available, not "under development".
2. You must provide the write-up following the standard format which is:

Name of program:
 6502 system(s) it works on:
 Memory required:
 Language used (Assembler, BASIC,...):
 Hardware required:
 Description of program:
 Number of copies in circulation:
 Price:
 Includes: (Cassette, Source listings,...)
 Author:
 Available from:

THE MICRO HARDWARE CATALOG

In issue number 6 we printed a call for hardware information for a Hardware Catalog. The formats of the material we received was so varied, that we have decided to impose a format for the sake of a more useful presentation of the material. To participate in this catalog, you must follow these rules:

1. The product must be currently available, either in stock or within four weeks delivery on new orders. Some units must have already been successfully delivered.
2. You must provide the write-up following the standard format which is:

Name of product:
 6502 systems it works with:
 Other hardware required:
 Power requirements:
 Description of product:
 Number of units delivered to date:
 Price:
 Includes: (Manuals, Cables,...)
 Developed by:
 Available from:

A lot of material that has been received for the Catalogs has not been in a useable format. We are not trying to make it difficult for you to submit your material. We are trying to make it easy for the readers to understand your product. We do not understand your product as well as you do and can not therefore do as good a write-up as you can. And, we don't have any more time than you do! So, please submit your stuff in the requested format and we will print it.

6502 RELATED COMPANIES

In issue number 1 we printed a list of companies that we were aware of which produced products of interest to the 6502 world. It is time to update the list. If you feel that your company should be on the list, then send in the following information as soon as possible:

Name of company:
 Address:
 Telephone: (Optional)
 Person to contact: (Optional)
 Brief list of 6502 products: (Maximum of five typed lines, please)

While the Software and Hardware Catalogs will be appearing regularly in every issue, this list of 6502 Related Companies will only appear once, in issue number 8, the Dec/Jan issue. Therefore, send your information in as soon as possible.

CASSETTE TAPE CONTROLLER

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The ideal tape storage facility for micro-systems would be one in which the micro has complete control of all tape movement and play/record functions without "operator intervention" e.g. pushing buttons. Unfortunately most of us have budgets which only allow use of lower cost audio cassette units. Short of massive mechanical rebuilding, these units can only be externally controlled with a motor on/off function after the "operator" has set the proper record/play keys. All too often we goof and press the wrong button, have to move cassettes from one unit to another, or simply forget to set up the units at the right time.

The Cassette Tape Controller (CTC) described below offers a reasonably inexpensive capability as a compromise in the provision of automatic tape control for a KIM-1 system. CTC is a combination of a seven-IC hardware board and supporting software routines. It was developed to control two Pioneer Centrex KD-12 cassette units. The concept could be extended to more than two units or perhaps other models.

A summary of the functions provided are:

- (1) Provide software-driven capability to start and stop a specific tape recorder by opening/closing the "remote control" circuit of the recorder (normally controlled by a switch on an external microphone).
- (2) Provide software-driven capability to route the input (record) or output (playback) signals as appropriate.
- (3) Provide override manual controls (toggles) to also accomplish (1) and (2), above.
- (4) Light panel indicators (LEDs) associated with the play or record functions selected for each cassette unit as set by software or manual controls.
- (5) Sense whether the selected tape recorder is set to play or record, or neither.
- (6) Sense the position of auxiliary toggles for setting software options, etc., (option switches).
- (7) Light indicators (LEDs) associated with the auxiliary toggles for operator communications.
- (8) Provide an audible "beep" under software control.

CTC General Description

The Cassette Tape Controller is a hardware/software facility to assist in the operation and use of audio cassette tape recorders for data read/write functions. The hardware provides the interface from a KIM-1 to two Pioneer Centrex KD-12 tape recorders. Besides the cassette input and output lines from KIM-1 four other lines (bit ports) are required for software control of the hardware.

The software and hardware control the recorder's motor circuits and determine if the appropriate manual keys on the recorder are set correctly. The software can provide alternative action (alert the operator or try another unit) in the case of improperly set keys.

The specific software illustrated below is written to "search" for a unit which is set in either a "read" (playback) or "write" (record) mode.

If none is found in the desired mode, an audible tone is sounded and the search is continued. The visible indication of each of the "read" or "write" LEDs blinking along with the audible tone provides the operator with a quick clue as to the erroneous settings. If the appropriate tapes are "mounted" the operator simply depresses the "requested" cassette unit key. Subsequent references by the software would locate the preset unit without communicating to the operator.

Additional facilities are built into the CTC hardware/software at little extra cost. These include the separately accessible audible tone and two option toggles with accompanying panel indicator LEDs. The toggles can be used for setting options selected by the operator and tested by the software. The associated indicators can also be used for some optional communication purposes. A third switch (momentary toggle or pushbutton) is used as a "break" command for software testing. A layout of the related hardware control panel is shown in Fig. 1.

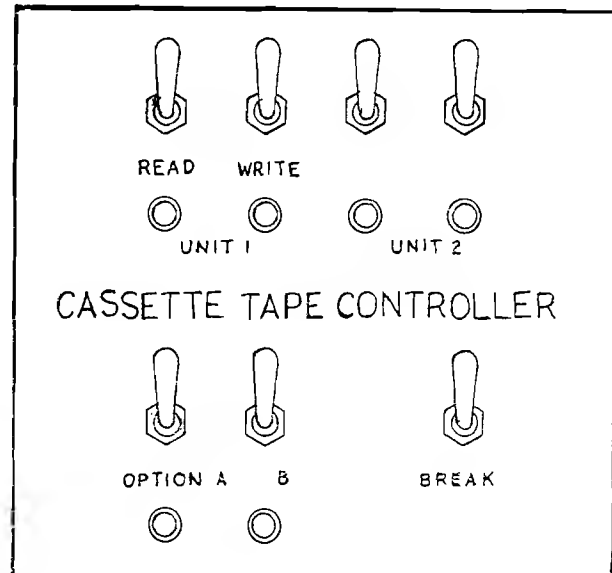


Figure 1.
Suggested Panel Layout
for Cassette Tape Controller

Hardware Description

A key to the logic of CTC is the ability to sense actual cassette unit key settings. By sensing voltage levels at two externally accessible points in the KD-12 circuitry it is possible to determine one of the following states:

- (1) unit set for read (playback) or fast forward or rewind
- (2) unit set for write (record)
- (3) no keys depressed

The circuit shown in Fig. 2 uses two ICs to address a function, one to enable and the other to sense results of enabling. This logic is further described in the comments accompanying the software source listing. Four non-critical DPDT relays are used to allocate signals and control

The KD-12 units are operated from external battery power (continually trickle-charged) to provide the most stable unit operation. HYPERTAPE speeds are extremely reliable in this configuration.

The controlling software consists of a series of routines which are accessible from user programs. The software shown in Fig. 3 is designed to "seek out" a cassette unit which is set for a given function, e.g., read. A brief study of the routines will show how this can be replaced or amended to select only a given cassette unit for a specific function. The additional routines are provided for "testing" the optional toggle switches, etc. Many of the routines are useful for other than tape cassette control, e.g., a JSR to BELL provides an audible "beep".

The hardware and software described have been working very satisfactorily on the author's system for well over a year. The CTC software (along with tape and record I/O routines based on the HYPERTAPE routines) have been committed to EPROM (2708). Access to this capability is easy and provides convenient operation of tape

Author's KIM Based System

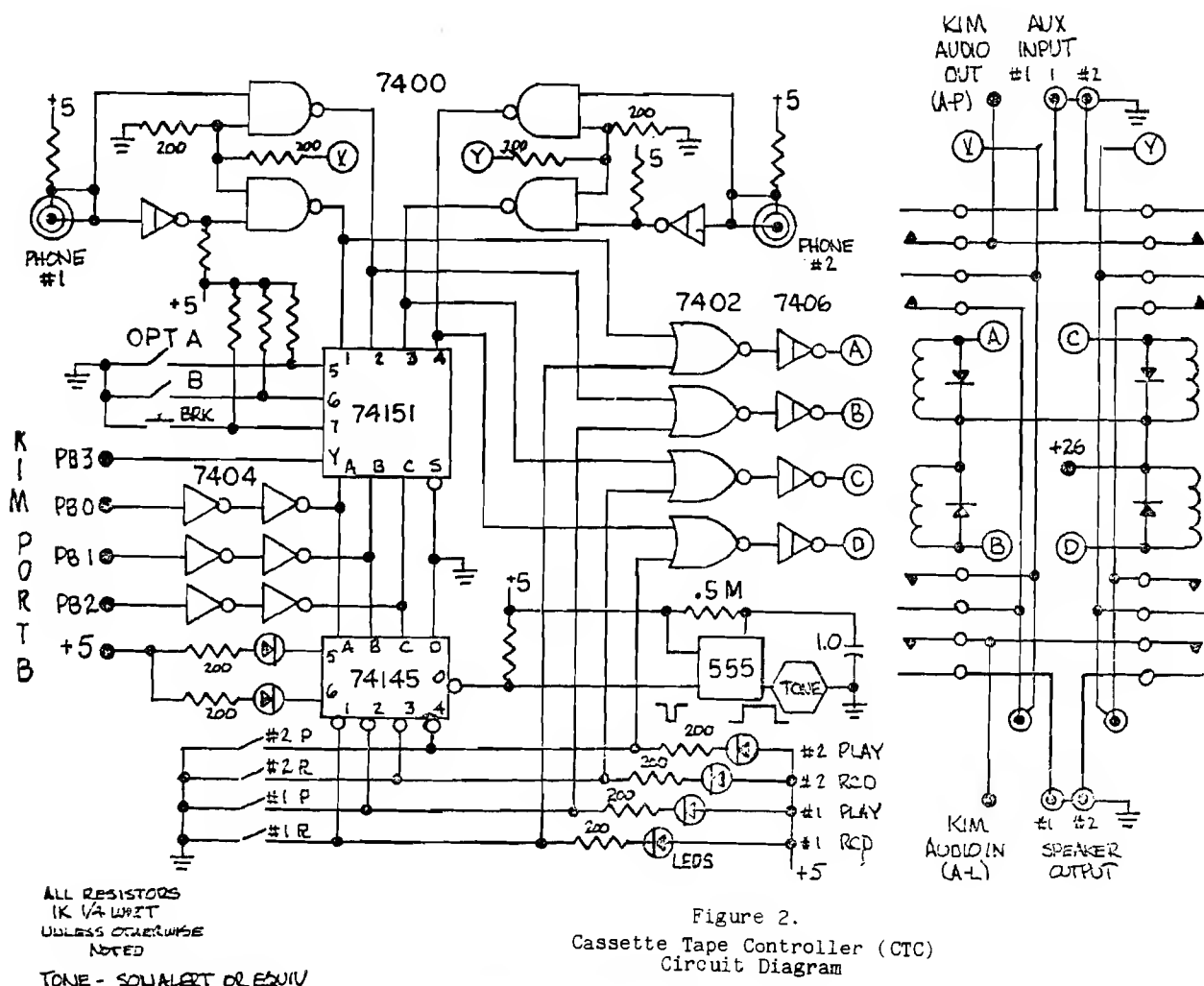


Figure 2.
Cassette Tape Controller (CTC)
Circuit Diagram

```

0010: 0200          KXFTAP ORG    $0200
0020:
0030:          *****
0040:          *                      *
0050:          *    CASSETTE TAPE    *
0060:          *  CONTROLLEF (CTC)  *
0070:          *    BY F.MILLER     *
0080:          *                      *
0090:          *****
0100:
0110:          *** KIM & ZERO PAGE PARAMETERS ***
0120:
0130: 0200          PEL      *      $1702
0140: 0200          PBLL     *      $1703
0150: 0200          TPFCT    *      $00EF
0160: 0200          INIT     *      $1E8C
ID=C2

0010:          *** TAPE CASSETTE READ ROUTINES ***
0020:
0030: 0200 D8          PRTAPE CLD
0040: 0201 A9 02          LLAIM $02      TEST FOR UNIT#1 READY
0050: 0203 20 1B 02          JSR  TPTEST FOR READ?
0060: 0206 F0 CC          BEQ   CREAL   ...YES
0070: 0208 A9 04          LLAIM $04      ...NO, UNIT#2 READY?
0080: 020A 20 1B 02          JSR  TPTEST
0090: 020D F0 05          BEQ   CREAL   ...YES
0100: 020F 20 2B 02          JSR  BELL    ...NO, SOUND SIGNAL AND
0110: 0212 D0 EC          ENR   PRTAPE TRY AGAIN.
0120:
0130: 0214 EA          CREAL  NOP
0140:          .
0150:          .
0160:          . ROUTINE FOR FEADING TAPE
0170:          . GOES HERE
0180:          .
0190:          .
0200:
0210: 0215 20 33 02          JSR  CTLOFF TURN OFF CASSETTE MOTOR
0220: 0218 4C 8C 1E          RLEXIT JMP  INIT    AND RETURN VIA KIM INIT
ID=C3

0010:          *** CASSETTE SUPPORT RTNS ***
0020:
0030: 021B 85 EF          TPTEST STA  TPFCT  SAVE UNIT/FCT
0040: 021D 8D 02 17          STA  PEL    FORT E CONTROL DATA
0050: 0220 20 3C 02          JSR  DELAY  ALLOW RELAY SETTLE
0060: 0223 AD 02 17          LLA  PEL    CK BITS 0-3 = TO
0070: 0226 29 0F          ANLIM $0F    ORIGINAL UNIT/FCT
0080: 0228 C5 EF          CMP   TPFCT
0090: 022A 6C          RTS          EQUAL MEANS UNIT READY
0100:
0110: 022E A9 CC          BELL  LLAIM $00
0120: 022D 8D 02 17          STA  PEL    ZERO FCT SETS TONE
0130: 0230 20 3C 02          JSR  DELAY  WAIT, RESET & EXIT
0140:
0150: 0233 A9 07          CTLOFF LLAIM $07  BITS 0-2 TO 0/F
0160: 0235 8D C3 17          STA  PBLL
0170: 0238 8D 02 17          STA  PEL    SET TO FCT#7 (OFF)
0180: 023E 6C          RTS

```

```

0190:
0200: 023C A9 FF      DELAY  LLAIM $FF
0210: 023E 8D 07 17   STA    $1707  SET TIMER TO 1/4 SEC
0220: 0241 2C 07 17   EIT    $1707
0230: 0244 10 FB      BPL    DELAY  +05
0240: 0246 60          RTS
0250:
0260: 0247 20 33 02   BRKCK  JSR    CTLOFF ENSURE OFF
0270: 024A 18          CLC
0280: 024E AD 02 17   LLA    PBL
0290: 024E 29 08      ANLIM  $08    BIT 3 HIGH MEANS NO BRK
0300: 0250 D0 01      BNE    BKEXIT
0310: 0252 38          SEC
0320: 0253 60      BKEXIT  RTS          NO CARRY MEANS NO BRK
ID=04

0010:
0020:                *** CASSETTE WRITE ROUTINE ***
0030:
0040: 0254 D8      WRTAPE  CLD
0050: 0255 A9 01      LLAIM  $01    TEST FOR UNIT#1 READY
0060: 0257 20 1B 02   JSR    TPTEST FOR WRITE?
0070: 025A F0 0C      BEQ    CWRITE ...YES
0080: 025C A9 03      LLAIM  $03    ...NO, TEST UNIT#2
0090: 025E 20 1B 02   JSR    TPTEST
0100: 0261 F0 05      BEQ    CWRITE ...YES
0110: 0263 20 2B 02   JSR    BELL    ...NO, SOUND SIGNAL AND TRY
0120: 0266 D0 EC      BNE    WRTAPE AGAIN
0130:
0140: 0268 EA      CWRITE  NOP
0150:
0160:
0170:
0180:
0190:
0200:
0210: 0269 20 33 02   JSR    CTLOFF TURN OFF MOTORS
0220: 026C 4C 8C 1E   JMP    INIT    AND RETURN VIA KIM
ID=05

0010:                *** ALT.SW TEST & LIGHT ***
0020:
0030: 026F A9 06      TSTSVA LLAIM $06    SET FOR ALT.SW #1
0040: 0271 D0 02      BNE    TSTSVE +02
0050:
0060: 0273 A9 05      TSTSVE LLAIM $05    SET FOR ALT.SW #2
0070: 0275 48          FRA          SAVE CODE
0080: 0276 20 33 02   JSR    CTLOFF INITL PORTS
0090: 0279 68          PLA          RETRIEVE CODE
0100: 027A 20 1B 02   JSR    TPTEST AND TEST SW
0110: 027D 18          CLC
0120: 027E D0 01      BNE    TSTX    IF NOT EQUAL
0130: 0280 38          SEC          MEANS SW IS NOT SET
0140: 0281 4C 33 02   TSTX    JMP    CTLOFF CARRY MEANS SW 'ON'
ID=

```


APPLE II HIGH RESOLUTION GRAPHICS MEMORY ORGANIZATION

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One of the most interesting, though neglected, features of the Apple II computer is its ability to plot on the television screen in a high resolution mode. In this mode, the computer can plot lines, points and shapes on the TV display area in greater detail than is possible in the color graphics mode (GR) which has a resolution of 40 x 48 maximum.

In the high resolution (HIRES) mode, the computer can plot to any point within a display area 280 points wide and 192 points high. While this resolution may not seem impressive to those who have used plotters and displays capable of plotting hundreds of units per inch, it is nonetheless capable of producing a very complex graphic presentation. This may be easily visualized by considering that a full screen display of 24 lines of 40 characters is "plotted" at the same resolution. An excellent example of the HIRES capability is included in current Apple II advertisements.

Why, then, has relatively little software appeared that uses the HIRES features? One of the reasons may be that little information has been available regarding the structure and placement of words in memory which are interpreted by HIRES hardware. Information essential to the user who wishes to augment the Apple HIRES routines with his own, or to explore the plotting possibilities directly from BASIC. In a fit of curiosity and Apple-insomnia, I have PEEKed and POKEd around in the HIRES memory area. The following is a summary of my findings. Happy plotting!

Each page of HIRES Graphics Memory contains 8192 bytes. Seven bits of each byte are used to indicate a single screen position per bit in a matrix of 280H x 192V. The eighth bit of each byte is not used in HIRES and the last eight bytes of every 128 are not used.

The bits in each byte and the bytes in each group are plotted in ascending order in the following manner. First consider the first two bytes of page 1. (Page 2 is available only in machines with at least 24K).

BYTE	8192														8193													
SCREEN POSITION	0	1	2	3	4	5	6	7	8	9	10	11	12	13														
BIT	0	1	2	3	4	5	6	0	1	2	3	4	5	6														
	V	G	V	G	V	G	V	G	V	G	V	G	V	G														

(Bit 7 not used)

V = VIOLET
G = GREEN

Figure 1 represents the screen position and respective bit & word positions for the first 14 plot positions of the first horizontal line. If the bit is set to 1 then the color within the block will be plotted at the position indicated. If the bit is zero, then black will be plotted at the indicated position. It can be seen that even bits in even bytes plot violet, even bits in odd bytes plot green and vice versa. Thus all even horizontal positions plot violet and all odd horizontal positions plot green. To plot a single white point, one must plot the next higher or lower horizontal position along with the point, so that the additive color produced is white. This is also true when plotting single vertical lines.

The memory organization for HIRES is, for design and programming considerations, as follows:

Starting at the first word, the first 40 bytes (0-39) represent the top line of the screen (40 bytes x 7 bits = 280). The next 40 bytes, however, represent the 65th line (i.e., vertical position 64). The next 40 bytes represent the line at position 128 and the next 8 bytes are ignored. The next group of 128 bytes represent three lines at positions 8, 72 and 136, the next group at positions 16, 80 and 142, and so on until 1024 bytes have been used. The next 1024 bytes represent the line starting at vertical position 1 (second line down) in the same manner. Eight groups of 1024 represent the entire screen. The following simple program provides a good graphic presentation as an aid to understanding the above description. Note that there is no need to load the HIRES machine language routines with this program. Set HIMEM:8191 before you type in the program.

```

100 REM SET HIMEM:8191
110 REM HIRES GRAPHICS LEARNING AID
120 POKE -16304,0: REM SET GRAPHICS MODE
130 POKE -16297,0: REM SET HIRES MODE
140 REM CLEAR PAGE - TAKES 20 SECONDS
150 FOR I=8192 TO 16383: POKE I,0: NEXT I
160 INPUT "ENTER BYTE (1 to 127)", BYTE
170 POKE -16302,0: REM CLEAR MIXED GRAPHICS
180 FOR J=8192 TO 16383: REM ADDRESS'
190 POKE J,BYTE: REM DEPOSIT BYTE IN ADDRESS
200 NEXT J
210 POKE -16301,0: REM SET MIXED GRAPHICS
220 GOTO 160
999 END

```

An understanding of the above, along with the following equations will allow you to supplement the HIRES graphics routines for memory efficient programming of such things as: target games, 3D plot with hidden line suppression and 3D rotation, simulation of the low resolution C=SCRN (X,Y) function, etc. Also, you may want to do some clever programming to put flags, etc., in the unused 8128 bits and 512 bytes of memory!

HI RES Graphics Equations and Algorithms

Where:

FB = ADDRESS OF FIRST BYTE OF PAGE.
 PAGE 1 = 8192 PAGE 2 = 16384
 LH = HORIZONTAL PLOT COORDINATE. 0 TO 279
 LV = VERTICAL PLOT COORDINATE. 0 TO 191
 BV = ADDRESS OF FIRST BYTE IN THE LINE OF
 40
 BY = ADDRESS OF THE BYTE WITHIN THE LINE
 AT BV
 BI = VALUE OF THE BIT WITHIN THE BYTE
 WHICH CORRESPONDS TO THE EXACT POINT
 TO BE PLOTTED.

Given: FB, LH, LV

BV = $LV \text{ MOD } 8 * 1024 + (LV/8) \text{ MOD } 8 * 128 + (LV/64) * 40 + FB$
 BY = $LH/7 + BV$
 BI = $2^{(LH \text{ MOD } 7)}$

To Plot a Point (Without HIRES Plot Routine):

LH = $X \text{ MOD } 280$: LV = $Y \text{ MOD } 192$ (OR)
 LV = $192 - Y \text{ MOD } 192$
 FB = 8192
 BV = $LV \text{ MOD } 8 * 1024 + (LV/8) \text{ MOD } 8 * 128 + (LV/64) * 40 + FB$
 BY = $LH/7 + BV$
 BI = $2^{(LH \text{ MOD } 7)}$
 WO = PEEK (BY)
 IF $(WO/BI) \text{ MOD } 2$ THEN (LINE NUMBER + 2)
 POKE BY, BI + WO
 RETURN

To Remove a Point, Substitute:

IF $(WO/BI) \text{ MOD } 2 = 0$ THEN (LINE NUMBER + 2)
 POKE BY, WO-BI

To Test a Point for Validity, the Statement:

"IF $(WO/BI) \text{ MOD } 2$ " IS TRUE FOR A PLOTTED POINT
 AND FALSE (=0) FOR A NON PLOTTED POINT.

RIVERSIDE ELECTRONIC DESIGN'S KEM AND MVM-1024:

A USER'S EVALUATION

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The price and availability of a variety of memory and application boards for the S 100 bus will make many KIM-1 owners think about expanding their systems to be compatible with this bus. The KIM Expansion Module (KEM) does the trick. In addition, one of the most attractive I/O modes is the keyboard/video monitor team. Riverside's MVM-1024, which interfaces neatly with the KEM, provides all the necessary circuitry to provide a 16 line by 64 character display on a video monitor. Programs which give the user a variety of display functions (homing the cursor, backspace, erase-a-line, etc.) and allow the user to communicate with the computer by way of the keyboard are also available from Riverside. Finally, all of the hardware and software is well documented in a series of application notes.

Space does not allow a complete description of all of the packages mentioned above. The reader should obtain the application notes and descriptions from Riverside if he is contemplating expansion. Summarily, the KEM buffers all of the address and data lines from the KIM-1, separating the latter into IN and OUT busses as required by the S 100; provides the necessary memory-mapped I/O ports for the keyboard, cursor, and video display; provides the logic for the S 100 signals; and provides four locations for the 1K 2708 EPROMs, in which may be stored display/monitor programs, PROM programmer software, or your favorite games.

The KEM does all of this without affecting any of the I/O ports on the KIM-1. That is, PAD and PBD may still be accessed from a connector on the KEM. The MVM-1024 contains its own memory and does not use any of the memory on the KIM-1. ASCII from the keyboard is loaded from address 13F8. To display a character, ASCII code for the character is stored in location 13FB. The cursor is controlled by the contents of two locations, 13F9 which contains a six bit word which determines the location of the character in a line, and 13FA which contains a four bit word which determines the line being used. Of course, the display/monitor programs do all of the necessary loading (LDA) and storing (STA) for you, but it is particularly easy to write short programs or subroutines which read the keyboard and/or output data on the video monitor

The danger in writing an equipment evaluation like this is in making it so concise that it is Greek to everyone except the hardened computer addict. So, I will conclude by saying that I was very satisfied with the performance of the Riverside hardware and software. I particularly liked their use of premium components such as LS TTL, the fact that the KIM-1 I/O ports are still available for applications, the keyboard polling software which allows the user to use NMI or IRQ interrupts for applications and the 4K of PROM space. Also, it is much easier to enter and de-bug programs with the display/monitor software. My only criticism is that it is not easy to lay out the system in a small package form.

A DIGITAL CLOCK PROGRAM FOR THE SYM-1

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The SYM-1 is a one board hobbyist computer similar to the KIM but with a number of additional features. Since buying the SYM-1 I have had a great deal of fun playing around with both the software and hardware sides of it. The SYM-1 monitor, Supermon, is an incredible monitor in 4K ROM, some of its sub-routines are called by the following program.

This program started off as a lesson in familiarity with the 6502 instruction set and using the Supermon subroutines to advantage, but the present version has been modified many times in order to increase the clock accuracy and, as my knowledge of the 6502 instruction set grows, increase coding efficiency. To use it one should start execution at :200. Then enter an "A" or "P" (Shift ASCII 5 0) to signify AM or PM. Then enter the hours (two digits), the program then outputs a space to separate the hours from the minutes. Finally enter 2 digits to signify the minutes, the program will then increment the minutes by 1, and begin the clock sequence. This slight quirk makes it easier to set the clock using another clock, set up the "A" or "P", hours and first digit of the minutes, then enter the last digit of the minutes as the seconds counter of your setting clock reaches 0.

There is another slight quirk in that the clock counts "A11 59", "A12 00", "A12 01", ..., "A12 59", "P01 00", "P01 01" This simplifies the programming and means that 12:30 near midday is in fact, 12:30 AM according to this clock! However this is not likely to confuse many people.

After setting up the initial time, the program adds 1 to the minutes and then carries on any carry into the hours, possibly changing "A" to "P" or vice versa. This section of the program could be made more efficient with full exploita-

tion of the 6502 instruction set. The last section in the program is a 1 minute delay. I have rewritten this section many times in a search for an accurate 1 minute delay. The first part is a double loop which also scans the clock display, this loop takes about 59.8 seconds. The second part is a double loop to "tweak" the delay up to 60 seconds and consists of 2 delays using the onboard 6532 timer. This timer is initialised in 1 of 4 memory locations, specifying ± 1024 , ± 64 , ± 8 , or ± 1 timing, e.g., the location to write to if one wants ± 1024 timing is A417. This location thus initialised is counted down in the 6532. The program reads this value until it becomes negative, at which time the delay is over.

Some improvements to the program could be made, for example better coding in the increment minutes section. One could also add an alarm feature, possibly using the on board beeper. The section to update the time by one minute could be used as a part of a background real time clock, being called by a once-a-minute hardware interrupt generated by an on board 6522 timer chip. Once a minute, processing would be interrupted for 100 cycles or so in order to update the real time clock. Such clocks have many uses, one of which is to ensure that certain number-crunching programs don't get tied down in big loops.

This improved version occupies less RAM by using jumps to INBYTE rather than INCHAR and messy bit manipulations. The delay routine has been improved to use the on board 6532 timer, and also give greater resolution and hence greater timing accuracy.

Editor's Note: This program is present primarily for its value in showing how to access the SYM's monitor for some of the routines. It is not an "optimal" program for a 24 hour clock, but should be a good starting point for owners of SYMs who wish to write similar programs.

SYM-1 ELECTRONIC CLOCK

BY CHRIS SULLIVAN AUGUST 27, 1978

```
ORG    $0200

SPACE *    $0020  ASCII SPACE
ACCESS *    $8B86
INCHAR *    $8A1B
INBYTE *    $81D9
OUTCHR *    $8A47
OUTBYT *    $82FA

0200 20 86 8B BEGIN JSR  ACCESS
0203 20 1B 8A      JSR  INCHAR GET A OR P
0206 85 00        STAZ $00
0208 18          CLC
0209 20 D9 81     JSR  INBYTE GET HOURS
020C 85 01        STAZ $01
020E A9 20        LDAIM SPACE SPACE CHARACTER
0210 20 47 8A     JSR  OUTCHR OUTPUT A SPACE
0213 20 D9 81     JSR  INBYTE GET MINUTES
0216 85 02        STAZ $02
0218 F8          SED      SET DECIMAL MODE FOR REMAINDER OF PROGRAM
```

HAVING SET THE INITIAL TIME (LESS 1 MINUTE)
UPDATE THE TIME:

```

0219 18          TIMLOP CLC
021A A5 02      LDAZ $02    GET MINUTES
021C 69 01      ADCIM $01    INCREMENT
021E 85 02      STAZ $02
0220 38          SEC
0221 E9 60      SBCIM $60    TEST IF NEW HOUR
0223 F0 03      BEQ TIMEX
0225 4C 50 02   JMP NORSET IF NOT A NEW HOUR

0228 A9 00      TIMEX LDAIM $00
022A 85 02      STAZ $02    SET MINUTES TO 00
022C 18          CLC
022D A5 01      LDAZ $01
022F 69 01      ADCIM $01    INCR HOURS
0231 85 01      STAZ $01
0233 38          SEC
0234 E9 13      SBCIM $13    TEST HOURS = 13
0236 F0 03      BEQ TIMEY
0238 4C 50 02   JMP NORSET

023B A9 01      TIMEY LDAIM $01    YES, SET HOURS TO 1
023D 85 01      STAZ $01
023F A5 00      LDAZ $00    GET A OR P
0241 49 50      EORIM $50    ASCII P
0243 F0 07      BEQ TIMEZ    IS 00 = ASCII P?
0245 A9 50      LDAIM $50    NO, THEN SET 00 TO P
0247 85 00      STAZ $00
0249 4C 50 02   JMP NORSET
024C A9 41      TIMEZ LDAIM $41    YES, THEN SET 00 TO A
024E 85 00      STAZ $00

0250 A5 00      NORSET LDAZ $00    GET A OR P
0252 20 47 8A   JSR OUTCHR
0255 A5 01      LDAZ $01    GET HOURS
0257 20 FA 82   JSR OUTBYT
025A A9 20      LDAIM SPACE
025C 20 47 8A   JSR OUTCHR
025F A5 02      LDAZ $02    GET MINUTES
0261 20 FA 82   JSR OUTBYT
0264 D8          CLD        CLEAR DECIMAL MODE
0265 A2 C0      LDXIM $C0    SETUP FOR ALMOST 60 SEC WAIT
0267 A0 7D      LDYIM $7D    COUNTER
0269 A9 01      WAITB LDAIM $01    NON-DISPLAYING CHARACTER
026B 20 47 8A   JSR OUTCHR REFRESH DISPLAY
026E 88          DEY
026F D0 F8      BNE WAITB    LOW ORDER COUNTER
0271 CA          DEX        HIGH ORDER COUNTER
0272 D0 F3      BNE WAITA
0274 A2 02      LDXIM $02    TWEAK TIME UP TO 60 SECONDS
0276 A9 4D      WAITC LDAIM $4D
0278 8D 17 A4   STA $A417    DIVIDE BY 1024 TIMER
027B AD 06 A4   WAITD LDA $A406 REGISTER OF 6532
027E 10 FB      BPL WAITD
0280 CA          DEX
0281 D0 F3      BNE WAITC
0283 F8          SED
0284 4C 19 02   JMP TIMLOP

```

VERIFY from 0200 thru 0286 is 356F.

The following subroutines called form part of the SYM-1's SUPERMON monitor:

ACCESS Enables the user program to write to system RAM, i.e. the RAM contained on the 6532. It is necessary to call ACCESS before calling most of the other system subroutines.

INCHAR Get one ASCII charcter from the input device (here the hex keypad) and return with it in the A register.

INBYTE Get two ASCII characters from the input device, using INCHAR and pack into a single byte in the A register.

OUTCHR Output the ASCII data in the A register to the output device (here the six digit LED display).

OUTBYT Convert the byte in the A register into two ASCII characters and output these to the output device.

Location A417 is used to initialise the 6532 timer to count down from the value stored in A417, with a divide by 1024 cycles. Thus the timer register on the 6532 is decremented by one every 1024 clock cycles. The timer register sits at location A406, and the time is considered to be "up" when the value at A406 becomes negative.

PEEKING AT PET'S BASIC

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Commodore, for reasons best known to them, has seen fit to prevent users from PEEKing at PET's ROM located, 8K BASIC. If you try to run a program that says, PRINT PEEK (49152), the answer returned will be zero instead of the actual instruction or data in decimal. Disassemblers written in BASIC will therefore not work properly if they use the PEEK command and try to disassemble 8K BASIC (decimal locations 49152 to 57520). I was curious to see how the PET's 8K BASIC was implemented and decided to write a machine language program which circumvents the restriction.

A listing of the above program which I have called MEMPEEK follows. It is decimal 22 bytes long, relocatable, and can be stored into any convenient area of memory. I have chosen to use the area devoted to the second cassette buffer starting at hex 33A. As long as the second cassette is not used the program should remain inviolate until the PET is turned off. Storing the program in memory is trivial if a machine language monitor is available. Otherwise convert the hex values to decimal and manually poke the values into memory. As of this writing, Commodore's free, long-awaited, TIM-like monitor has not arrived but I continue to hope.

MEMPEEK utilizes the user function (USR) which jumps to the location stored in memory locations 1 and 2. If MEMPEEK is stored in the second cassette buffer (hex 33A) initialize locations 1 and 2 to decimal 58 and 3 respectively. MEMPEEK was written so that the user function returns the decimal value of the instruction given by its argument (address). For example, if you want to peek at an address less than decimal 32768 (not part of the BASIC ROMs) use in your program Y=USR (address), where address is the location of interest and the value of Y is set to the instruction at that address. Since the argument of the user function is limited to +32767, use address -65536 for addresses larger than 32768. Thus to look at locations in the BASIC ROMs (all above 32768 and where MEMPEEK is particularly useful) use Y=USR (address -65536). It is not possible to look at location 32768 (the start of the screen memory) with this program but this should prove no handicap as PEEK could be used.

MEMPEEK takes advantage of two subroutines in the PET operating system. The first (located at hex D0A7) takes the argument (address) in the floating point accumulator (conveniently placed there by the user function) and converts it into a two byte integer stored at hex B3 and B4. Since I choose to use an indirect indexed instruction to find the desired instruction the order of the two bytes at hex B3 (MSB) and B4 (LSB) need to be reversed. The second subroutine at hex D278 converts a 2 byte integer representing the instruction from the accumulator (MSB) and the Y register (LSB) to floating point form and stores it in the floating point accumulator. This value, the instruction, is returned to BASIC as the result of the user function.

The program, MEMPEEK, is fairly simple but would be unnecessary if the arbitrary restriction on PEEKing at BASIC was removed. The restriction makes no sense to me as even a relatively inexperienced machine language programmer (myself) was able to get around it. This type of program would of course not be difficult for competitors of Commodore to write. I wrote this program for the fun of it, to try to understand how BASIC works and in the hope others will find it useful. Furthermore, I hope I can discourage other manufacturers like Commodore from trying to keep hobbyists from a real understanding of their software by arbitrary restrictions.

MEMPEEK Program

033A	1	*=\$33A
033A	2	JSR \$D0A7 ; convert to integer
033D	3	LDX \$B3 ; interchange -
033F	4	LDY \$B4 ; \$B3 and \$B4
0341	5	STX \$B4
0343	5	STY \$B3
0345	7	LDX #0 ; initialize index
0347	8	LDA (\$B3,X); find instruction
0349	9	TAY
034A	10	LDA #0
034C	11	JSR \$D278 ; convert to floating
034F	12	RTS ; return to BASIC
0350	13	END



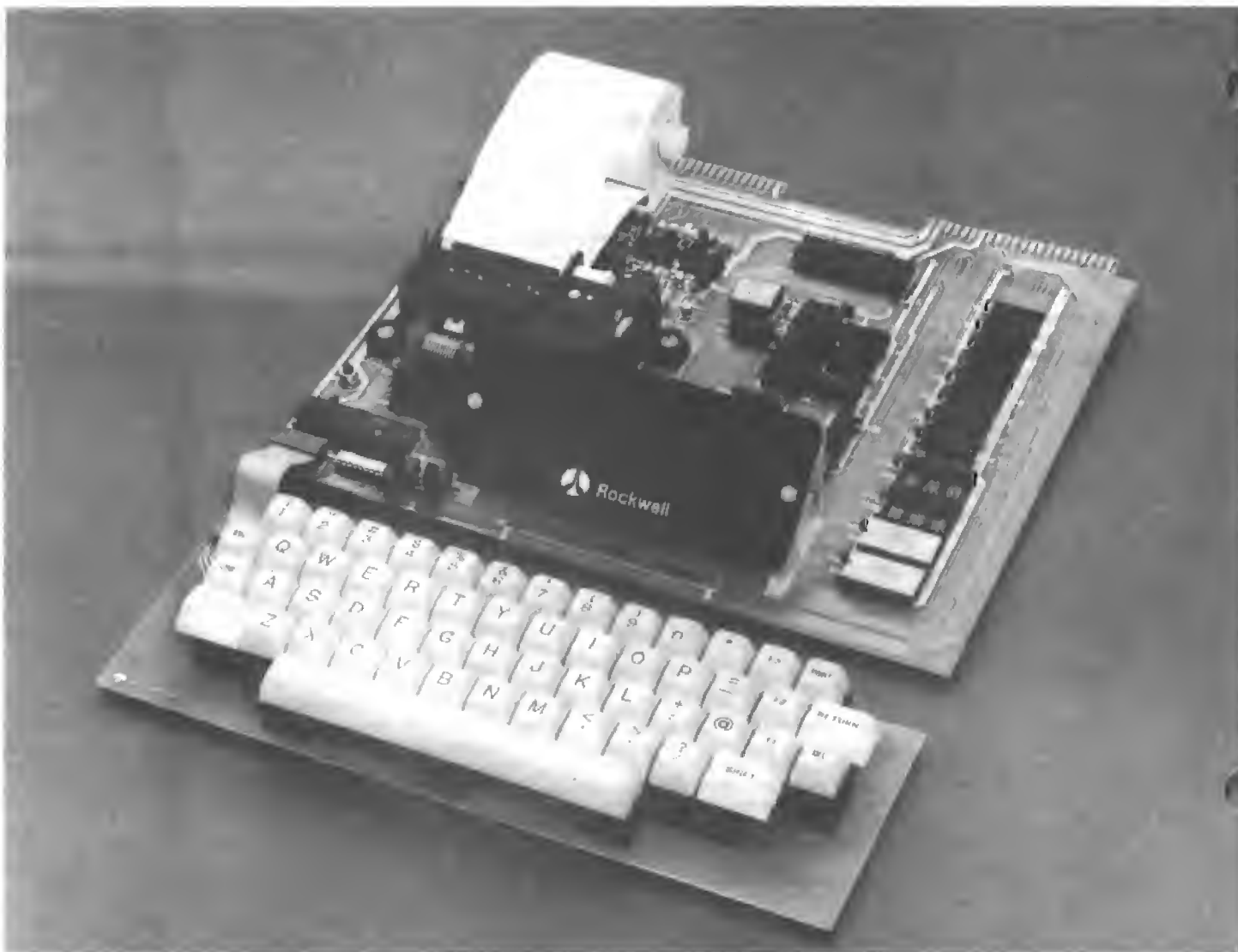
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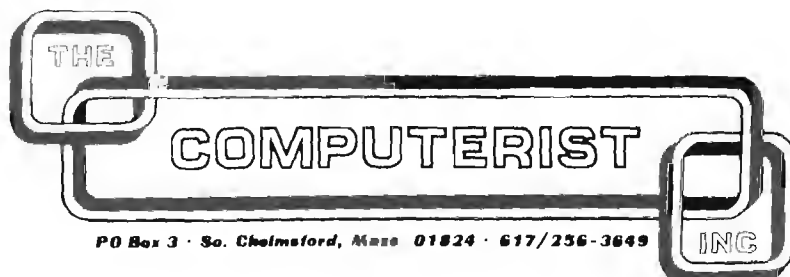
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KIMBASE

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KIMBASE is an application program written in the 6502 microprocessor machine language, designed to make use of the monitor subroutines and memory configuration of the KIM-1 microcomputer, for conversion of unsigned integers from one base to another. The input integer (designated NUMBER is to be no greater than 6 digits in length; large 6-digit integers may cause overflow in the multiplication subroutines with consequent errors in conversion. The base to be converted from (designated BASE1) and to be converted to (BASE2) are each in the range from 02_H to 10_H; the lower limit is set by mathematical reality and the upper by the limited enumeration available from the KIM-1 keypad.

The program is started by placing NUMBER, lowest order byte last, in page zero 4C-4E, BASE1 (expressed in hexadecimal) in 4A, and BASE2 (also in hexadecimal) in 4B. The program starts at 0200, and will light up the KIM-1 LED display with either an error message (according to an error flag stored in zero page 02, called ERROR), or a result display with the input data and a final result up to 18_H digits in length (RESULT stored in 03-0E) in successive segments in a format to be discussed below, or a combination of both displays, in an endless loop until the RS key is pressed.

Program Function

After initialization of data workspace, several tests of input data validity are conducted. KIMBASE recognizes four error states:

- NUMBER will remain same after conversion (i.e. NUMBER=00000x where x is less than either base). KIMBASE sets ERROR=01, RESULT=NUMBER, and shows both error and result displays.
- Either or both bases are outside the permissible limits of 02-10_H. KIMBASE resets bases under 02 to equal 02 and bases exceeding 10_H to equal 10_H, and executes program to display result without an error display.
- BASE1=BASE2. KIMBASE sets ERROR=02, RESULT=NUMBER, and shows error and result displays.
- NUMBER enumeration is impermissible, as one or more digits =BASE1 (e.g., attempting NUMBER=1C352A with BASE1=05). KIMBASE sets ERROR=03, shows error display, and aborts further execution.

Note that error states "a" and "c", above, are not mutually exclusive, and that KIMBASE sets the error flag ERROR and goes to the appropriate response routine after only one positive test. Errors are displayed as a continuous flashing LED readout "ErrorY" where Y=ERROR.

KIMBASE - MAIN PROGRAM LISTING

***** this section initializes data workspace and constants *****

	CLD	0200	D8	select binary mode
	LDX \$#48	01	A2 48	set workspace byte counter
ZERO1	LDA \$#00	03	A9 00	
	STA ARRAY,X	05	95 01	zero common workspace
	DEX	07	CA	decrement counter
	BNE ZERO1	08	D0 F9	if #0 loop back
	LDA \$#0F	0A	A9 0F	
	STA MASK1	0C	85 0F	set MASK1=0F
	LDA \$#F0	0E	A9 F0	
	STA MASK2	10	85 10	set MASK2=F0

Following the test routines, if BASE1≠10_H, KIMBASE converts NUMBER into its hexadecimal equivalent by successive generation of powers of BASE1, multiplication of the appropriate power by the individual digits of NUMBER (remapped by masking and shifting into array N), and successive addition of all the hexadecimal products. This intermediate result is placed in array HEXCON. A successive loop algorithm was used for multiplication rather than a shift-and-binary-add algorithm for economy of coding.

$$\text{HEXCON} = \left[\sum_{y=1-6} N(Y) * \text{BASE1}^{(y-1)} \right]_{10}$$

This calculation is bypassed and NUMBER entered directly into HEXCON if BASE1=10_H.

After the conversion to hexadecimal, if BASE2=10_H, KIMBASE sets RESULT=HEXCON and the result display is initiated. If BASE2≠10_H, HEXCON is converted into BASE2 by the common successive division procedure by BASE2 with mapping of remainders through an intermediate array into RESULT.

Results are displayed on the KIM-1 6-digit display as successive 1-second displays of NUMBER, BASE1 and BASE2, and RESULT divided into 6-digit segments, in the format:

NNNNNN	(NUMBER1-NUMBER3)
Iibboo	(II=BASE1; OO=BASE2)
RRRRRR	(RESULT1-RESULT3)
RRRRRR	(RESULT4-RESULT6)
RRRRRR	(RESULT7-RESULT9)
RRRRRR	(RESULTA-RESULTC)

which loops endlessly. Where ERROR=01 or 02, the error message precedes the result display, and loops endlessly in the display.

All intermediate arrays and products have been retained in the zero page data workspace to facilitate any debugging or further elaboration of the program that other users may find necessary.

Users of non-KIM 6502-based microcomputers may implement KIMBASE easily with appropriate relocation of program and workspace (if necessary) and replacement of the display subroutines (SHOWER-TIMER1, SHORES-TIMER2) with appropriate machine-dependant output routines (or by BRK instructions with manual interrogation of the appropriate arrays to determine output).

LDA	\$#05	12	A9	05	
STA	PWR	14	85	00	set PWR=05
LDX	\$#FF	16	A2	FF	
TXS		18	9A		set stack pointer=FF

***** this section tests input data validity *****

TST1NR	LDA	\$#00	19	A9	00	TEST - ERROR STATE "a"
	CMP	NUMBER1	1B	C5	4C	NUMBER1=00?
	BNE	TST1BS	1D	D0	14	no? go to next test
	CMP	NUMBER2	1F	C5	4D	NUMBER2=00?
	BNE	TST1BS	21	D0	10	no? go to next test
	LDA	NUMBER3	23	A5	4E	
	CMP	BASE2	25	C5	4B	NUMBER3< BASE2?
	BCC	CORR1	27	90	03	yes? go to correction routine
	JMP	TST1BS	29	4C	33	02 go to next test
CORR1	LDA	\$#01	2C	A9	01	
	STA	ERROR	2E	85	02	set ERROR=01
	JMP	CORR3A	30	4C	5A	02 and jump to CORR3A
TST1BS	LDX	\$#02	33	A2	02	TEST - ERROR STATE "b"
TST1B2	LDA	BASE,X	35	B5	49	
	CMP	\$#02	37	C9	02	BASE(X) < 02?
	BCC	CORR2A	39	90	0B	yes? go to correction routine
	CMP	\$#11	3B	C9	11	BASE(X) ≥ 11?
	BCC	RESET1	3D	90	0B	no? bypass correction
CORR2B	LDA	\$#10	3F	A9	10	
	STA	BASE,X	41	95	49	otherwise set BASE(X)=10
	JMP	RESET1	43	4C	4A	02 and bypass next correction
CORR2A	LDA	\$#02	46	A9	02	
	STA	BASE,X	48	95	49	set BASE(X)=02
RESET1	DEX		4A	CA		decrement loop counter
	BNE	TST1B2	4B	D0	E8	and go back if #0
TST2BS	LDA	BASE2	4D	A5	4B	TEST - ERROR STATE "c"
	CMP	BASE1	4F	C5	4A	BASE2=BASE1?
	BEQ	CORR3	51	F0	03	yes? go to correction routine
	JMP	TST3BS	53	4C	6A	02 otherwise bypass
CORR3	LDA	\$#02	56	A9	02	
	STA	ERROR	58	85	02	set ERROR=02
CORR3A	LDX	\$#03	5A	A2	03	
	LDY	\$#0C	5C	A0	0C	
CORR3B	LDA	NUMBER,X	5E	B5	4B	read NUMBER
	STA	RESULT,Y	60	99	02	00 into RESULT
	DEY		63	88		decrement counters
	DEX		64	CA	
	BNE	CORR3B	65	D0	F7	and loop until complete
	JSR	SHOWER	67	20	A0	00 display error message
TST3BS	LDA	BASE1	006A	A5	4A	
	CMP	\$#10	6C	C9	10	BASE1=10?
	BCC	TST2NR	6E	90	0C	no? go to next test
	LDX	\$#03	70	A2	03	
HEXMAP	LDA	NUMBER,X	72	B5	4B	yes? read NUMBER
	STA	HEXCON,X	74	95	25	into HEXCON
	DEX		76	CA		
	BNE	HEXMAP	77	D0	F9	for all 3 bytes
	JMP	HEX1	79	4C	1F	03 and bypass hex conversion
TST2NR	LDA	BASE1	7C	A5	4A	TEST - ERROR STATE "d"
	STA	BSTR1	7E	85	11	store BASE1
	ASL	ASL	80	0A	0A	
	ASL	ASL	82	0A	0A	and left shift 4 bits
	STA	BSTR2	84	85	12	to store BSTR2=(10*BASE1)
	LDY	\$#02	86	A0	02	
TLP2	LDX	\$#03	88	A2	03	
TLP1	LDA	NUMBER,X	8A	B5	4B	isolate each digit NUMBER(X)
	AND	MASK,Y	8C	39	0E	00 by masking
	CMP	BSTR,Y	8F	D9	10	00 and compare with BSTR
	BCC	TRESET	92	90	03	if less, reset loop
	JMP	CORR4	94	4C	A0	02 otherwise impermissible - correct
TRESET	DEX		97	CA		decrement counter NUMBER
	BNE	TLP1	98	D0	F0	and repeat for corresponding digits
	DEY		9A	88		decrement counter BSTR/MASK
	BNE	TLP2	9B	D0	EB	and repeat for remaining digits
	JMP	REMAP	9D	4C	A7	02 go to REMAP
CORR4	LDA	\$#03	A0	A9	03	
	STA	ERROR	A2	85	02	set ERROR=03
	JSR	SHOWER	A4	20	A0	00 and display error message

***** this section remaps NUMBER for conversion to hex *****

REMAP	LDX \$#03	A7	A2	03	
REMAP1	LDA NUMBER,X	A9	B5	4B	load NUMBER
	STA NHI,X	AB	95	12	into NHI
	STA NLO,X	AD	95	15	and into NLO
	DEX	AF	CA		
	BNE REMAP1	B0	D0	F7	loop until done
	LDX \$#03	B2	A2	03	
MASKS1	LSR NHI,X	B4	56	12	right shift
	LSR NHI,X	B6	56	12	NHI
	LSR NHI,X	B8	56	12	4 bits
	LSR NHI,X	BA	56	12
	LDA NLO,X	BC	B5	15	
	AND MASK1	BE	25	0F	isolate right digit NLO
	STA NLO,X	C0	95	15	
	DEX	C2	CA		
	BNE MASKS1	C3	D0	EF	loop until done
	LDY \$#01	C5	A0	01	
	LDX \$#03	C7	A2	03	
REMAP2	LDA NLO,X	C9	B5	15	store NLO into N
	STA N,Y	CB	99	18 00	
	INY	CE	C8		alternately
	LDA NHI,X	CF	B5	12	with NHI
	STA N,Y	D1	99	18 00	and in inverse order
	INY	D4	C8		
	DEX	D5	CA		
	BNE REMAP2	D6	D0	F1	loop until done

***** this section converts N into hexadecimal *****

HEXCNV	LDY \$#06	02D8	A0	06	for six places
LP1PWR	JSR PWRGEN	DA	20	60 00	generate powers of BASE1
	LDA N,Y	DD	B9	18 00	
	CMP \$#01	E0	C9	01	N(Y)=01?
	BEQ RESET3	E2	F0	0B	if equal, go to RESET3
	BCC RESET5	E4	90	15	if less, go to RESET5
	STA MULTP	E6	85	1F	set MULTP=N(Y)
RESET2	TYA	E8	98		put index Y into accumulator
	PHA	E9	48		and push onto stack
	JSR MULT	EA	20	80 00	multiply power by N(Y)
	PLA	ED	68		pull accumulator from stack
	TAY	EE	A8		and restore to Y
RESET3	CLC	EF	18		
	LDX \$#03	F0	A2	03	
RESET4	LDA MULTC,X	F2	B5	1F	add new product
	ADC HEXCON,X	F4	75	25	to intermediate product
	STA HEXCON,X	F6	95	25	and store as intermediate product
	DEX	F8	CA		
	BNE RESET4	F9	D0	F7	loop until done
RESET5	DEY	FB	88		for next place
	BEQ HEX1	FC	F0	21	if counter=0 bypass
	DEC PWR	FE	C6	00	reduce power to be generated
	LDA PWR	0300	A5	00	
	CMP \$#01	02	C9	01	PWR=01?
	BEQ RESET6	04	F0	02	yes? go to RESET6
	BCS LP1PWR	06	B0	D2	greater? loop back to new conversion
RESET6	LDA N,Y	08	B9	18 00	
	STA MULTC3	0B	85	22	set MULTC=N(Y)
	LDA \$#00	0D	A9	00	
	STA MULTC1	0F	85	20	
	STA MULTC2	11	85	21	
	LDA BASE1	13	A5	4A	
	STA MULTP	15	85	1F	set MULTP=BASE1
	LDA PWR	17	A5	00	
	CMP \$#01	19	C9	01	PWR=01?
	BEQ RESET2	1B	F0	CB	yes? go to RESET2
	BCC RESET3	1D	90	D0	less? go to RESET3

***** this section produces result from HEXCON when BASE2=10 *****

HEX1	LDA BASE2	1F	A5	4B	
	CMP \$#10	21	C9	10	BASE2=10?
	BCC ZERO2	23	90	10	no? go to ZERO2
	LDY \$#0C	25	A0	0C	
	LDX \$#03	27	A2	03	

```

HEX2    LDA  HEXCON,X      29    B5 25      store HEXCON
        STA  RESULT,Y      2B    99 02 00    into RESULT
        DEY                      2E    88
        DEX                      2F    CA
        BNE  HEX2          30    D0 F7      loop until done
        JSR  SHORES        32    20 90 03    and display result

***** this section divides HEXCON by BASE2 for crude conversion *****

ZERO2    STA  DIVIS          0335    85 2C      set DIVIS=BASE2
        LDX  $#03          37    A2 03
LP1DIV    LDA  HEXCON,X      39    B5 25      load HEXCON
        STA  DIVD,X        3B    95 28      into DIVD
        DEX                      3D    CA
        BNE  LP1DIV        3E    D0 F9      loop until done
        LDY  $#18          40    A0 18      for 18H places
LP2DIV    JSR  DIVIDE        42    20 10 01    execute division
        LDA  RDR           45    A5 30      load RDR
        STA  RSTOR,Y       47    99 30 00    into RSTOR
        LDX  $#02          4A    A2 02
TST1QO    LDA  QUO,X         4C    B5 2C
        CMP  $#01          4E    C9 01      QUO(1 or 2)2=01?
        BCS  RESET7        50    B0 09      yes? go to RESET7
        DEX                      52    CA
        BNE  TST1QO        53    D0 F7      loop until done
        LDA  QUO3          55    A5 2F
        CMP  DIVIS         57    C5 2C      QUO3=DIVIS?
        BCC  ENDDIV        59    90 15      less? go to ENDDIV
RESET7    LDX  $#03          5B    A2 03
RST7A     LDA  QUO,X         5D    B5 2C      load QUO
        STA  DIVD,X        5F    95 28      into DIVD
        LDA  $#00          61    A9 00
        STA  QUO,X         63    95 2C      zero QUO
        DEX                      65    CA
        BNE  RST7A        66    D0 F5      loop until done
        STA  RDR           68    85 30      zero RDR
        DEY                      6A    88      decrement place counter
        BEQ  ENDV2         6B    F0 09      if =0 go to ENDV2
        JMP  LP2DIV        6D    4C 42 03    otherwise back to divide routine
ENDDIV    DEY                      70    88      decrement place counter
        LDA  QUO3          71    A5 2F      load QUO3
        STA  RSTOR,Y       73    99 30 00    into next RSTOR slot

***** this section maps RSTOR into RESULT for final result *****

ENDV2    LDY  $#0C          76    A0 0C
        LDX  $#18          78    A2 18
        CLC                      7A    18
REMAP3    DEX                      7B    CA
        LDA  RSTOR,X       7C    B5 30      left shift alternate bytes
        ASL  ASL           7E    0A 0A      RSTOR 4 bytes
        ASL  ASL           80    0A 0A      .....
        INX                      82    E8
        ADC  RSTOR,X       83    75 30      add to next byte RSTOR
        STA  RESULT,Y      85    99 02 00    and store as RESULT
        DEY                      88    88
        DEX                      89    CA
        DEX                      8A    CA
        BNE  REMAP3        8B    D0 EE      loop until done
        JSR  SHORES        8D    20 90 03    and display result

```

1. PWRGEN

Subroutine to generate a^b by successive iterations of multiplication subroutine MULT with resetting of counters and intermediate products; allows unsigned binary or decimal arithmetic in 6502 instruction set; maximum result memory allocated 18_H bits.

Requires: subroutines: MULT 0080-009B

data arrays: BASE1 004A
PWR 0000
PWRS 0001
MULTP 001F
MULTC 0020-0022

Inapplicable to PWR=00,01; calling program must test and bypass.

PWRGEN	LDA	PWR	0060	A5 00	load power
	STA	PWRS	62	85 01	store in counter
	DEC	PWRS	64	C6 01	decrement counter
	LDA	BASE1	66	A5 4A	
	STA	MULTP	68	85 1F	set multiplier=base
	STA	MULTC3	6A	85 22	set multiplicand=base
	LDA	\$#00	6C	A9 00	
	STA	MULTC1	6E	85 20	zero 2 high-order bytes
	STA	MULTC2	70	85 21	of multiplicand
	TYA		72	98	transfer index Y to accumulator
	PHA		73	48	and onto stack
MULTCL	JSR	MULT	74	20 80 00	jump to MULT
	DEC	PWRS	77	C6 01	decrement counter
	BNE	MULTCL	79	D0 F9	if #0 return to MULTCL
	PLA		7B	68	pull accumulator from stack
	TAY		7C	A8	and restore to index Y
	RTS		7D	60	return to main program

2. MULT

Subroutine multiplies 24-bit number (MULTC) by 8-bit number (MULTP) to yield 24-bit final product (MULTC) by successive iterations of nested addition loops. Intermediate product storage in MIDPRO. Allows unsigned decimal or binary operation in 6502 instruction set.

Requires : data arrays : MULTP 001F
 MULTC 0020-0022
 MIDPRO 0023-0025

Inapplicable to MULTP less than 02; calling program to test and bypass

MULT	LDY	MULTP	0080	A4 1F	loop counter=multiplier
	DEY		82	88	decrement loop counter
	LDX	\$#03	83	A2 03	set byte counter in loop
REDIST	LDA	MULTC,X	85	B5 1F	set intermediate register
	STA	MIDPRO,X	87	95 22	=multiplier
	DEX		89	CA	for each byte in array
	BNE	REDIST	8A	D0 F9	loop until X=0
ADLP2	LDX	\$#03	8C	A2 03	set byte counter in loop
	CLC		8E	18	clear carry
ADLP1	LDA	MULTC,X	8F	B5 1F	add multiplicand
	ADC	MIDPRO,X	91	75 22	to intermediate product
	STA	MULTC,X	93	95 1F	store as new multiplicand
	DEX		95	CA	for each byte in array
	BNE	ADLP1	96	D0 F7	loop until X=0
	DEY		98	88	decrement loop counter
	BNE	ADLP2	99	D0 F1	another loop if Y#0
	RTS		9B	60	return to main program

3. DIVIDE

Subroutine to divide 24-bit dividend (DIVD) by 8-bit divisor (DIVIS) to yield 24-bit quotient (QUO) and 8-bit remainder (RDR) by successive shift and subtraction processes; unsigned binary arithmetic only in 6502 instruction set. Intermediate quotient storage in QUO. Requires initialization of RDR and array QUO to 0 by calling program, DIVIS#0.

Requires : data arrays : DIVD 0029-002B
 DIVIS 002C
 QUO 002D-002F
 RDR 0030

DIVIDE	LDX	\$#19	0110	A2 19	load shift counter
LOOP1	ASL	RDR	12	06 30	left shift remainder
	ASL	QUO3	14	06 2F	left shift quotient LSB
LOOP1A	BCS	HIQUO1	16	B0 28	go to incrementing routine
					if carry set
	ASL	QUO2	18	06 2E	left shift quotient mid-byte
	BCS	HIQUO2	1A	B0 2F	go to incrementing routine
					if carry set
	ASL	QUO1	1C	06 2D	left shift quotient MSB

LOOP2	CLC	1E	18	clear carry
	ASL DIVD3	1F	06 2B	left shift dividend LSB
	BCS HIORD1	21	B0 2F	go to incrementing routine if carry set
	ASL DIVD2	23	06 2A	left shift dividend mid-byte
	BCS HIORD2	25	B0 36	go to incrementing routine if carry set
	ASL DIVD1	27	06 29	left shift dividend MSB
LOOP3	BCS INCR	29	B0 39	go to incrementing routine if carry set
LOOP4	DEX	2B	CA	decrement shift counter
	BEQ FINIS	2C	F0 3B	jump to end if X=0
	SEC	2E	38	set carry
	LDA RDR	2F	A5 30	from current remainder
	SBC DIVIS	31	E5 2C	subtract divisor
	BMI LOOP1	33	30 DD	back to LOOP1 if negative
	STA RDR	35	85 30	store difference as remainder
	ASL RDR	37	06 30	left shift remainder
	ASL QUO3	39	06 2F	left shift quotient LSB
	INC QUO3	3B	E6 2F	increment quotient LSB
	JMP LOOP1A	3D	4C 16 01	and go back to LOOP1A
HIQUO1	ASL QUO2	40	06 2E	left shift quotient mid-byte
	INC QUO2	42	E6 2E	and increment it
	BCS HIQUO2	44	B0 05	go to further incrementing routine if carry
	ASL QUO1	46	06 2D	left shift quotient MSB
	JMP LOOP2	48	4C 1E 01	and back to LOOP2 (if C=0)
HIQUO2	ASL QUO1	4B	06 2D	left shift quotient MSB
	INC QUO1	4D	E6 2D	increment quotient MSB
	JMP LOOP2	4F	4C 1E 01	and back to LOOP2
HIORD1	ASL DIVD2	52	06 2A	left shift dividend mid-byte
	INC DIVD2	54	E6 2A	increment dividend mid-byte
	BCS HIORD2	56	B0 05	go to further incrementing routine if carry
	ASL DIVD1	58	06 29	left shift dividend MSB
	JMP LOOP3	5A	4C 29 01	and back to LOOP3 (if C=0)
HIORD2	ASL DIVD1	01 5D	06 29	left shift dividend MSB
	INC DIVD1	5F	E6 29	increment dividend MSB
	JMP LOOP3	61	4C 29 01	and back to LOOP3
INCR	INC RDR	64	E6 30	increment remainder
	JMP LOOP4	66	4C 2B 01	and back to LOOP4
FINIS	LSR RDR	69	46 30	right shift remainder to end
	RTS	6B	60	return to main program

4. SHOWER & TIMER1

Subroutines to generate error message for display on the KIM-1 6-digit LED readout by successive lighting of appropriate segments of the individual digits using a message lookup table.

SHOWER requires: subroutines: TIMER1 00DE-00E9 timing loop for display
SHORES 0390-03CF result display for ERROR=01 or 02

: data arrays: SADD 1741}
SBDD 1743}
SAD 1740}
SBD 1742}
ERROR 0002
MSGERR 00D6-00DA
MSGNUM 00DB-00DD

monitor storage for readout

SHOWER	LDA \$#7F	00A0	A9 7F	
	STA SADD	A2	8D 41 17	set output directional vector A=7F
	LDA \$#1E	A5	A9 1E	
	STA SBDD	A7	8D 43 17	set output directional vector B=1E
DISP2	LDY \$#08	AA	A0 08	set digit selection counter
	LDX \$#05	AC	A2 05	set loop counter
DISP1	STY SBD	AE	8C 42 17	select digit
	LDA MSGERR,X	B1	B5 D5	select segments
	STA SAD	B3	8D 40 17	to be lit (from lookup table)
	JSR TIMER1	B6	20 DE 00	and jump to timing loop
	INY	B9	C8	select next digit

INY	BA	C8	
DEX	BB	CA	decrement loop counter
BNE DISP1	BC	D0 F0	if #0 loop again
LDA \$#12	BE	A9 12	
STA SBD	C0	8D 42 17	for sixth digit
LDX ERROR	C3	A6 02	set index to error flag
LDA MSGNUM,X	C5	B5 DA	and select segments
STA SAD	C7	8D 40 17	to be lit (from lookup table)
JSR TIMER1	CA	20 DE 00	and jump to timing loop
LDA ERROR	CD	A5 02	
CMP \$#03	CF	C9 03	if ERROR=03
BEQ DISP2	D1	F0 D7	loop same display again
JMP SHORES	D3	4C 90 03	otherwise jump to show result

lookup tables:

00D6	D0 DC D0 D0 F9	MSGERR
00DB	86 DB CF	MSGNUM

TIMER1 requires: interval timer location 1707

TIMER1	LDA \$FF	00DE	A9 FF	set timer for approximately
	STA 1707	E0	8D 07 17	200 milliseconds per digit
DELAY1	NOP	E3	EA	do nothing but light segments
	BIT 1707	E4	2C 07 17	time up?
	BPL DELAY1	E7	10 FA	no? keep lit
	RTS	E9	60	yes? back to SHOWER for next digit

5. SHORES & TIMER2

Subroutines to generate result display on the KIM-1 6-digit LED readout by loading appropriate data into array DISP for display by KIM monitor subroutine SCANDS.

SHORES requires: subroutines: TIMER2 03D0-03E5 timing loop for display
SHOWER 00A0-00D5 error display for ERROR=01 or 02

: data arrays: ERROR 0002
RESULT 0003-000E
BASE 004A-004B
NUMBER 004C-004E
DISP 00F9-00FA monitor storage for readout:
00F9 INH
00FA POINTL
00FB POINTH

SHORES	LDY \$#01	0390	A0 01	set index for DISP
	LDX \$#03	92	A2 03	set index for NUMBER
LOADN1	LDA NUMBER,X	94	B5 4B	put NUMBER into DISP
	STA DISP,Y	96	99 F8 00	
	INY	99	C8	increment DISP index
	DEX	9A	CA	decrement NUMBER index
	BNE LOADN1	9B	D0 F7	loop until DISP is full
	JSR TIMER2	9D	20 D0 03	and jump to timing/display loop
	LDA BASE1	A0	A5 4A	load BASE1
	STA POINTH	A2	85 FB	into two highest digits
	LDA \$BB	A4	A9 BB	load BB
	STA POINTL	A6	85 FA	into two middle digits
	LDA BASE2	A8	A5 4B	load BASE2
	STA INH	AA	85 F9	into two lowest digits
	JSR TIMER2	AC	20 D0 03	and jump to timing/display loop
	LDX \$#01	AF	A2 01	set index for RESULT
LOADN3	LDY \$#03	B1	A0 03	set index for DISP
LOADN2	LDA RESULT,X	B3	B5 02	put RESULT (3 bytes at a time)
	STA DISP,Y	B5	99 F8 00	into DISP
	INX	B8	E8	increment RESULT index
	DEY	B9	88	decrement DISP index
	BNE LOADN2	BA	D0 F7	loop until DISP is full
	TXA	BC	8A	put RESULT index into accumulator

FHA		BD	48		and push onto stack
JSR	TIMER2	BE	20 D0 03		now jump to timing/display loop
PLA		C1	68		pull accumulator from stack
TAX		C2	AA		and put in RESULT index X
CPX	\$#0D	C3	E0 0D		is X > 0C?
BCC	LOADN3	C5	90 EA		if not, loop back to load DISP
LDA	ERROR	C7	A5 02		if yes, does ERROR=00?
CMP	\$#00	C9	C9 00		
BEQ	SHORES	CB	F0 C3		if yes, loop again for whole display
JMP	SHOWER	CD	4C A0 00		otherwise show error

TIMER2 requires: subroutines: SCANDS 1F1F monitor display subroutine

data arrays: CTLP 0049
interval timer location 1707

TIMER2	LDA	\$#05	03D0	A9	05	
	STA	CTLP	D2	35	49	set loop counter
DSPN2	LDA	\$#FF	03D4	A9	FF	set timer for maximum run
	STA	1707	D6	8D	07 17	
DSPN1	JSR	SCANDS	D9	20	1F 1F	and call display subroutine
	BIT	1707	DC	2C	07 17	time up?
	BPL	DSPN1	DF	10	F8	no? maintain display
	DEC	CTLP	E1	C6	49	decrement loop counter
	BNE	DSPN2	E3	D0	EF	if #0, reset timer and maintain display
	RTS		E5	60		otherwise back to SHORES for next entry



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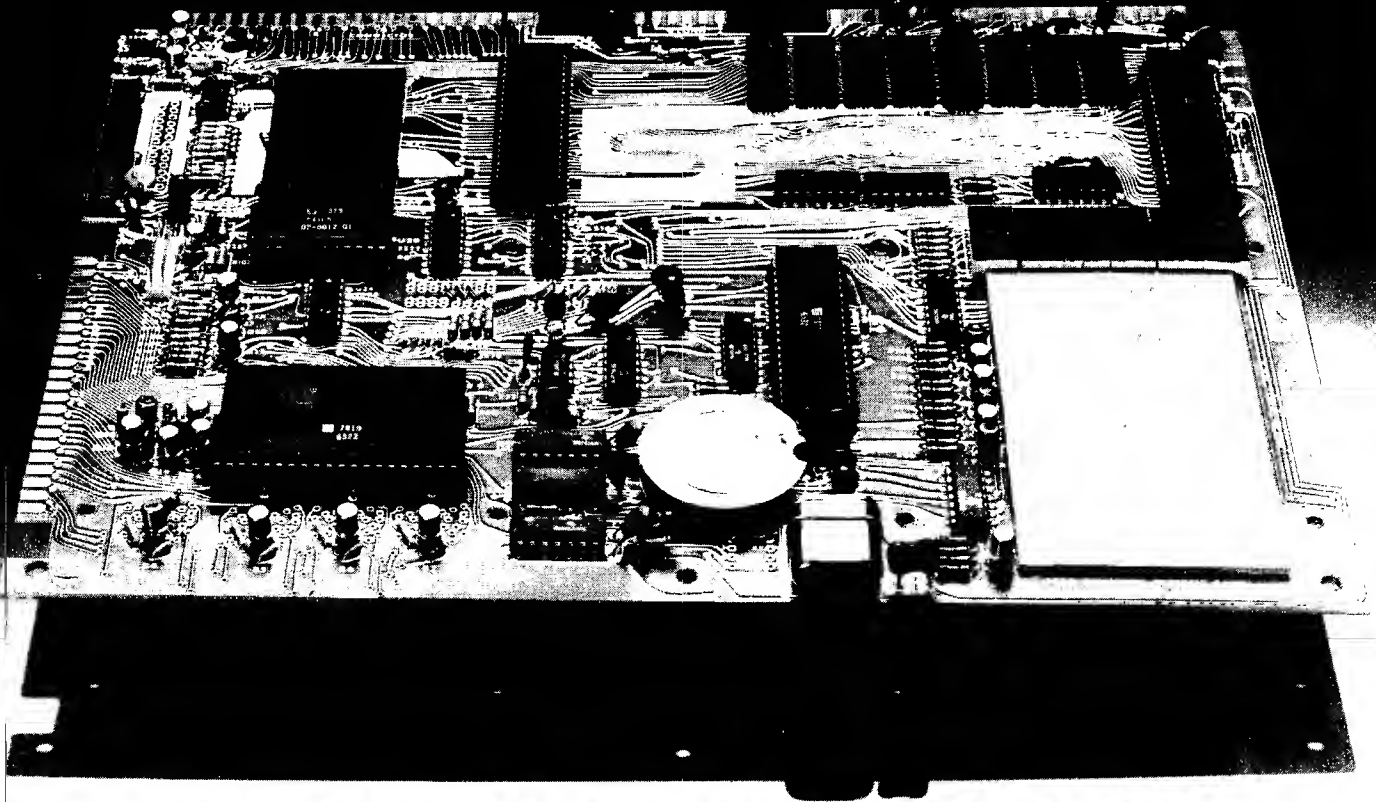
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